

UNIVERSITY OF BRISTOL.



THE ANNUAL REPORT

OF THE

Agricultural and Horticultural
Research Station

(THE NATIONAL FRUIT AND CIDER INSTITUTE)

LONG ASHTON, BRISTOL,

1933.

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INTRODUCTION.

By B. T. P. BARKER, M.A., Director.

At the outset of 1933 it was clear that the Department could not look forward to a year of stability and other conditions conducive to the steady development of its work, but it was hoped that a less difficult time than in 1932 might be experienced. Those hopes have not been realised and at each of the three main centres of its activities, the Campden and Long Ashton Research Stations and the Berkeley Square Advisory Centre, unavoidable circumstances have disturbed greatly the normal routine and hampered progress in many respects.

The death of Dr. H. B. Napier, the original Treasurer of the Department and Chairman of the Finance and Business Sub-Committee, at the end of 1932 involved considerable changes in those sides of the administration of the Department with which he had been directly and closely concerned for many years. In his place Dr. Hiatt C. Baker, Pro-Chancellor and Chairman of the General Purposes Committee of the University and one of the original members of the Finance and Business Sub-Committee of the Department, has been appointed Chairman of the latter body and Treasurer of the Long Ashton and Berkeley Square centres. He has also succeeded Dr. Napier as Chairman of the Governing Body of the National Fruit and Cider Institute. Taking over these responsibilities at so difficult a period, he has been faced with many problems of a critical order in his first year of office. The Department already owes much to him for the guidance which his wide experience of affairs and lengthy connection with its own work have enabled him to give. The Treasurership of the Campden Station has been accepted by Mr. A. Woodall, Managing Director of British Cannery, Ltd., and a member of the Campden Management Sub-Committee. The progress of the work of that Station and the important matters affecting its future now under consideration made it almost essential that a newly appointed Treasurer should be in much closer proximity and contact than anyone living in the Bristol district would be. Mr. Woodall possesses those qualifications and, in addition, has the advantage of an intimate association with the staff and work of the Station for some years past.

The publication of a separate Annual Report on the Campden Station, which has now become the rule, makes it unnecessary here to refer to matters of detail associated with its 1933 history. Mention will be made only of the lengthy absence of Mr. Hirst, the Resident Director, entailed by business visits to Palestine and the United States of America during the course of the summer. The former trip was arranged at the invitation of the Colonial Office and its special object was a survey of the grape fruit industry in that country in regard to the possibilities of development of an associated canning industry. The United States visit was arranged to enable Mr. Hirst to make a comprehensive tour of the more important areas associated with the canning industry in that country, by means of which he could gain first-hand contact with the research and technical developments there. Since his return he has prepared two reports on these tours which should prove of particular value to the Empire industry at this critical stage in the history of its development. During his absence Mr. W. B. Adam deputised for him as Resident Director.

Illness and staff changes, in some cases consequent thereon, greatly hampered the progress of work at the Long Ashton Station and the Berkeley Square Advisory Centre. That the adverse effect was not more serious must be attributed mainly to the loyal co-operation and endeavour of other members of the staff. Through their efforts the general services of both centres were maintained to a degree which reflects much credit on them.

Unsettling and difficult as these enforced breaks and changes have been, the outstanding serious feature of the year has been the financial situation. While in some previous years the strictest economy has been imperative, at no time in the past history of the Department have events prevented income and expenditure from being fairly evenly balanced. In 1933, however, it met with an abnormal combination of circumstances which entailed a heavy financial loss on the year's working. The severe cuts in the grants received through the Ministry of Agriculture and Fisheries which were made in 1931 in consequence of the financial crisis of the country and the reductions in certain county grants were continued: their effects were intensified by the complete withdrawal of the Ministry's grant and those of the counties of Dorset and Monmouth in aid of the Scheme of Local Instruction in Cider Making. The termination of the five year period to which the Empire Marketing Board grant applied, coupled with the uncertainty at that time of the future of the Board itself, resulted in temporary arrangements for the continuance of the special work in connection with that grant being made on a heavily reduced

scale, and in an even severer reduction in the sum provided for its maintenance. The income from sales of produce during the year was adversely affected by the consequences of a disastrous spring frost which caused a heavy loss of fruit crops, and by the falling off in the demand for draught cider which was to be expected as a sequel to the reduction of the duty on beer to which the Budget of 1933 gave effect. In addition, various abnormal and unavoidable non-recurring items of expenditure and losses of minor sources of income affecting the year in question have contributed materially to the financial problem.

Nevertheless, in the face of these various difficulties and changes there have been several encouraging features, important events and developments in connection with the Department during the year. Some lines of research have been marked by notable advances in knowledge and the Advisory Service has seen a large increase in the number of enquiries and requests for assistance. Steps have been taken to prevent a recurrence of the serious financial loss; in some directions the financial prospects have improved, although in others serious problems remain for solution. At the end of the year the outlook, both as regards finance and general working conditions, seems more hopeful than at any time earlier in its course.

THE BERKELEY SQUARE ADVISORY CENTRE.

Staff.

During the year three members of the staff who have been prominently associated with the work of the Centre have vacated their posts.

Mr. H. T. Horsman, B.Sc., of the Economics Branch, has been succeeded by Mr. D. F. Ruston, B.Sc., N.D.A.

Mr. G. T. Roy, of the same Branch, retired to accept a post in the Economics Branch of the Department of Agriculture at Armstrong College, Newcastle, and his place was filled by the appointment of Mr. E. C. W. Velten, B.Sc., B.A. The latter tragically met his death as the result of a motor accident in December. A successor will shortly be appointed.

The Dairy Bacteriologist, Mr. C. S. Miles, B.Sc., N.D.A., N.D.D., resigned at the end of May and was succeeded by Mr. J. W. EgdeU, B.Sc., N.D.A. The latter unfortunately contracted paratyphoid fever a few weeks later and was unable to resume work till October. During his absence Mr. N. R. Knowles, B.Sc., N.D.A., N.D.D.,

who was obtained at short notice from Reading University, took over the work in this subject temporarily.

General.

Notwithstanding the very considerable interference with the work of these respective branches, the activities of all sections at Berkeley Square have been maintained and extended. At the request of the Ministry of Agriculture an Economic Survey of the Willow-growing industry in Somerset has been undertaken and completed : a detailed report of the survey has been published. The newly established Poultry Pathology Laboratory has been in full working order throughout the year under the charge of Mr. J. S. Garside, M.R.C.V.S., D.V.S.M., the Poultry Pathologist, who is working in close association with Mr. W. D. Menzies, M.R.C.V.S., the Advisory Veterinary Officer. The counties of the Bristol Province have availed themselves extensively of the service of this laboratory, and the number of samples being submitted for test is increasing. The well-established services of the other branches of work at Berkeley Square continue to be in constantly increasing demand. Among the special investigations in hand is one concerned with the chemical composition of the herbage of grassland, many samples of which, obtained from the grassland experiments with which the Department has been so long associated, were awaiting examination. The cost of this work is being partly defrayed by a Special Investigation Grant made by the Agricultural Research Council.

LONG ASHTON RESEARCH STATION.

Staff.

Changes at this Station have not been numerous but they have involved the departure of two of the oldest members of the Staff, Messrs. O. Grove and F. Tutin, in each case owing to a breakdown in health.

Mr. Grove's appointment dates back to 1912, when, as a result of the arrangements under which the University became jointly responsible with the National Fruit and Cider Institute for the work at Long Ashton, the nucleus of a research staff was established. Since that time he has carried on the investigations in cider-making and related subjects which have made him widely known throughout the whole industry.

Mr. Tutin was one of the first comers to join the Staff after the end of the war, when a further extension of the Station became

possible. His name will always be associated with those investigations on the ovicidal properties of tar distillates which have led to the development of the modern forms of winter egg-killing washes.

The many who have derived benefit directly and indirectly from the researches of these two investigators will appreciate the loss the Station has sustained and join with it in deep regret at the cause.

Until the position at the Station in respect of the various lines of work associated with the subject of cider and other fruit products has become more stabilised, the arrangement made in the earlier stages of Mr. Grove's illness and reported upon a year ago, under which Mr. V. L. S. Charley is carrying on the research work in those subjects, with the collaboration of Mr. P. T. H. Pickford in the practical experiments in the ciderhouse and the advisory work, will be continued.

In succession to Mr. Tutin, Mr. Hubert Martin, M.Sc., F.I.C., has been appointed as Biochemist, and will continue his work on the Chemistry of Insecticides and Fungicides. The latter's reputation in this subject is well established through his researches at the South Eastern Agricultural College, Wye, and his text book on "Scientific Principles of Plant Protection."

During Mr. Tutin's absence owing to illness, Mr. T. J. P. Pearce, Ph.D., carried on some of the investigations in conjunction with the pathological staff of the Station. When he left in July, 1933, to take up an appointment with Imperial Chemical Industries, Ltd., Dr. J. Bloom, at that time engaged upon investigations on pyrethrins and related substances under a grant from the Colston Research Society, continued the work until Mr. Martin came into residence. Dr. Bloom's work at the Station has now ceased with the termination of the grant from the Colston Research Society.

Another newcomer to the staff is Mr. I. Dembrey, B.Sc., who was appointed in July, 1933, to conduct certain investigations connected with the use of sulphur dioxide in the preservation of fruit pulp, with the aid of a Special Investigation Grant from the Ministry of Agriculture. Towards the end of the year he was transferred to a new line of work, involving the examination of samples of National Mark jams, and his previous duties were taken over by Dr. J. C. Hinton, who by that time had been left without a definite post at the Station owing to the reduction of the Empire Marketing Board Grant for the Fruit Quality Investigations with which he had been previously associated.

The facilities available at the Station for research and study by

post-graduate and other students have been taken advantage of by several workers, as in other recent years.

Mr. D. V. Karmarkar, M.Sc., completed his investigations on certain features of the nitrogen metabolism of apple trees and was awarded the degree of Ph.D. by the University of Bristol for his work on that subject.

Two members of the assistant staff qualified for higher degrees in the University: Mr. D. A. Osmond, M.Sc., was awarded the degree of Ph.D. for work on the soils of the Evesham District, and Mr. F. C. Lewis, B.Sc., was granted the degree of M.Sc. for studies relating to the effects of orchard factors on the mineral content of fruits.

Miss M. Carleton, B.Sc., has continued her entomological investigations in conjunction with Dr. Kearns, and has been accepted by the University of Bristol as a candidate for the degree of M.Sc.

Mr. H. M. Hutchinson, B.Sc., has assisted Mr. L. Ogilvie in a study of root rots of the strawberry plant.

Mr. N. Colquhoun, B.Sc., has been associated with Mr. Charley in researches on the nitrogenous constituents and pectic compounds in fruit juices and products.

Messrs. H. Gough, of Birmingham, and T. G. Tomlinson, of Manchester University, each spent several weeks of study at Long Ashton, the former working in the Entomological Department under the supervision of Drs. Kearns and Walton, and the latter studying methods of mycological technique under the direction of Mr. Marsh in the Mycological Department.

The Station was visited for shorter periods by several research workers and other students from this country and overseas, who desired to get direct touch with the work of the Station.

Land and Buildings.

No additions to the permanent buildings of the Station have been made during the year, but it is clear that certain developments in that direction must be faced as soon as the general financial position allows. The laboratory side of the investigations on fruit products has already been carried almost to the point when semi-commercial scale experiments are necessary before this line of work can be proceeded with further usefully. These may necessitate an enlargement of the block of buildings now devoted to cider-making. Also the service housing scheme of the Station is still uncompleted and the addition of one house at least has now become urgent.

In respect of the development of the fruit plantation experiments, little extension has been possible during the past few years owing to the fact that practically the whole of the land suitable for such purposes in the possession of the Station was already fully planted up. Negotiations with the Ashton Court Estate have been in progress for some time with regard to an exchange of land whereby a block belonging to the Estate, adapted for experimental work and adjacent also to the Station's main plantations, could be acquired by the Station in return for the surrender of an area of outlying land, the property of the Station, unsuited for fruit culture but with potential value for building purposes and adjoining a building estate in course of development by Ashton Court. The exchange has now been completed, with the result that approximately 15 acres of unplanted land adapted for fruit culture have become available for extension purposes. This is now in course of preparation for planting.

The planting programme for 1933, for the reasons indicated, was limited in extent and concerned primarily with the establishment of new blocks of fruit in plots becoming vacant by the completion of previous experiments. Nearly two additional acres of the new Hillside orchard, to which reference was made in the Annual Report for 1932, were planted with standard trees of selected cider varieties, most of which satisfactorily survived the heat and drought of the abnormal summer which followed planting.

A $3\frac{1}{2}$ acre plot of strawberries was established on the site of the old raspberry variety trial plantations. The purpose of the plot is primarily to test various methods of field control of the more important and prevalent pests and diseases of the strawberry, in particular the new hot water treatment of runners prior to planting to control the Tarsonemid mite, and the pollination of the varieties Oberschlesien and Tardive de Leopold with Royal Sovereign.

The original manurial experiment with gooseberries has been completed, and the gooseberries have now been replaced with raspberries on the same plots, the manurial treatments being continued as hitherto.

Considerable additions have been made to the nursery programme. A large number of cider apple trees on various rootstocks to be trained in bush form are being propagated to serve for the establishment of the extensive trials of the culture of cider fruit planned at the Station and various selected centres elsewhere, under conditions of culture designed to give crop production more speedily than under the usual standard grass orchard system. This line of investigation has been undertaken at the suggestion of the Ministry of Agriculture in view of the prospective increasing shortage of

cider fruit in this country, due jointly to the growing demand for this fruit by the growth of the cider industry and the falling off in supplies in consequence of the great age and worn-out condition of the majority of the cider orchards in the cider producing districts.

As regards the propagation of soft fruits, several thousand black currant cuttings have been planted to serve for the interplanting of bushes of this fruit in the new Station plantation of bush cider apples referred to in the previous paragraph. After nearly ten years of close attention and rigorous roguing of material not up to standard, stocks of healthy and vigorous raspberries and strawberries have been established, and are being multiplied in the Station's nursery plots. These stocks are now believed to be unsurpassed in quality by any in the country, but as yet no attempt has been made to propagate on a scale sufficiently large to meet the requirements of commercial fruit growers.

General.

The Annual Open Field Day was held on Thursday, May 2nd, when as usual the plantations were open to inspection, and the Competition Ciders were available for sampling.

The special features of the day included demonstrations of (a) spraying appliances suitable for use in farm orchards, and (b) the use of explosives in tree felling and general preparation of land for tree planting. A comprehensive exhibit contributed by the Ministry of Agriculture and Fisheries, dealing with its National Mark schemes for the marketing of agricultural and horticultural produce, also attracted much attention.

The occasion was again favoured by fine weather and many visitors, including several from various fruit growing and other districts outside the West of England, took advantage of this opportunity of inspecting the work of the Station. In the unavoidable absence of Earl de la Warr, Parliamentary Secretary of the Ministry of Agriculture and Fisheries, the prizes in the Cider Competitions were distributed and a short and appropriate address given by Mr. H. V. Taylor, B.Sc., O.B.E., Commissioner of Horticulture of the Ministry. The thanks of the Station are especially due to him for undertaking this task at very short notice.

On several other occasions during the year the Station was visited by organised parties, including the following :—

- Science Masters' Association.
- Bristol Grammar School Scientific Society.
- Bristol Section and Food Group of the Society of Chemical Industry.
- Bristol University Botanical Society.
- Reading University Students.

Deputation from the French Chamber of Commerce.
 Somerset Beekeepers' Association.
 Transport and General Workers' Union.
 Sexey's School Pupils.
 South African Farmers.
 Clifton College Scientific Society.
 Bristol University Employees' Association.
 Temple Technical Old Boys' Society.
 Somerset Beekeepers' Association (Bristol Branch).
 Ministry of Agriculture and Fisheries Advisory Officers.
 Messrs. W. D. & H. O. Wills' Despatch Department.
 All Saints' (City) Branch of the Church of England Men's Society.
 Great Western Railway Employees.
 Midsomer Norton, Radstock and District Gardeners' Debating Society.
 Kingswood and District Employees Hospitality Guild.
 Fishponds Diocesan Training College.
 Bristol Cyclists' Touring Club.

The holding of the Imperial Fruit Show at Bristol for the first time brought many fruit growers and others interested in associated industries to the district. On this occasion the Station did not contribute its usual educational exhibit to the Show, owing to the limited space available for stands in the relatively small Coliseum building in which the Show was held: it was decided that a more adequate and satisfactory display should be staged at the Station itself, which was only 15 minutes' by car from the Show. This arrangement brought many visitors to Long Ashton and gave them an opportunity of seeing both the organised exhibit set out in the laboratory building and the general work of the Station in the fruit plantations and the cider house. The usual Growers' Day function, organised by "The Fruit Grower," was held during the course of the Show, and the programme on this occasion consisted of a series of papers contributed by members of the Long Ashton staff. The Station is indebted to the proprietors and editor of that Journal for placing that opportunity of bringing some of the more important features of its current work so prominently to the notice of so large and representative an audience of growers from all parts of the country.

The complete list of Shows to which the Department sent exhibits during the course of the year is as follows:—

Devon County Show, Honiton.
 Bath and West and Southern Counties Show, Wimbledou.
 Royal Horticultural Show, Chelsea.
 Three Counties Show, Worcester.
 Asparagus Growers' Show, Evesham.
 Cheltenham Spa Floral Fete, Cheltenham.
 International Lily Conference, London.
 Gillingham and Shaftesbury Show, Shaftesbury.
 Abergavenny Horse Show, Abergavenny.
 Imperial Fruit Show, Bristol.

Other contacts with growers continue to be widened through both the advisory and field research work. The former is referred

to in some detail in a separate article in this Report. The latter, as noted in other recent Reports, is constantly on the increase in plantations belonging to growers, in view of the necessity of studying as far as possible the problems in the locations where they arise, and of extending the investigations initiated in the Long Ashton laboratories to the varied conditions which obtain in the field in different localities. A general acknowledgement of the valuable service rendered in this connection by growers is given here most warmly for, apart from placing their plantations at the disposal of the Station for such purposes, they have spared neither personal trouble nor expense to secure the satisfactory conduct of the trials.

Work in collaboration or consultation with other institutions has also been continued. From time to time as publications of results are issued the individual centres concerned are specified, and there is thus no occasion here to set out in detail the individual items of such conjoint investigation : but it is appropriate to record here the gratification felt at the prospect of an early resumption of the annual staff conferences with the East Malling Station, which have had to be suspended during the past two years owing to the financial stress during that period and the uncertainty of the continuation of lines of work hitherto financed by grants from the late Empire Marketing Board.

It must not be omitted, in conclusion, to pay a very cordial tribute to the services of the non-graded and labour staffs of the Department. Through a very difficult period financially they have shared generously in the effort to maintain all sides of the work efficiently. Such success as has been obtained is due to them as well as to the members of the graded staff, whose work normally comes more to public notice.

CIDER FRUIT CULTURE IN RELATION TO MODERN REQUIREMENTS.*

By B. T. P. BARKER, M.A.

Since the writer contributed an article on "West Country Orchards and their Possibilities" to the 1922-23 Volume of the "Bath and West Journal," events affecting that subject have moved rapidly. The scope of the present article makes it unnecessary to discuss the bearing of recent developments upon the farm orcharding of the western counties in relation to the production of table fruit. Its concern is exclusively with the production of fruit for cider and perry making, and its conclusions may be regarded as summarising the results of the thirty years of investigations and experience on the subject at this station since its original establishment as the National Fruit and Cider Institute. In that connection the decade just ending has been a period during which certain vital issues have been forced into consideration. These call for attention before the main subject of this article can be dealt with in the light of present-day requirements.

RECENT DEVELOPMENTS IN THE CIDER INDUSTRY.

The position which cider as a commercial beverage has attained to-day has justified in many respects the optimistic anticipations which the prospect at the end of the war encouraged. It has achieved a widespread popularity in a comparatively short period of time. So rapid a rise in public favour has produced problems which need to be taken into serious account when the provision of the future supplies of the raw material for the industry is being planned.

The days when a large proportion of the total output of cider was made for use on the farm and the farm labourer was the largest type of consumer have passed. No longer is the local public house the outlet for the surplus of the farm produce. A different kind of market has been established, and other grades of consumers

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have been attracted. Cider has become a beverage in demand by all classes throughout the country. Popular taste is, however, notoriously fickle and fashions change in drinks as in other articles. No lack of confidence in the merits of the beverage or in its ultimate ability to hold its place is implied by the observation just made : but fluctuations in consumption, possibly at times wide in amount, must be expected from time to time and this risk should not be lost sight of in estimating requirements and planning supplies of fruit for the future.

Two factors have undoubtedly contributed largely to the advance in favour of cider as a drink for the general public. The first of these has been the relative decline in consumption of beer, resulting partly from the increased price of the latter and partly from its lowering in quality due to the enforced reduction of original-gravity standards. High taxation and legislative regulations have been responsible for these handicaps imposed upon beer and have enabled cider to make headway against this beverage, which has always been regarded as its main competitor. Neither of these conditions are necessarily permanent. The cider industry cannot rely upon the advantage gained on their account as anything more than a temporary benefit. It must be prepared to consolidate its position by the merits of cider itself rather than through the difficulties of the brewing industry. This point has been definitely illustrated during the past few months since the reduction of the beer duty in the last Budget.

The second factor favouring the consumption of cider has been the change in public taste from synthetic aerated drinks to beverages prepared from fruit juices. This advantage for cider is probably likely to be of a more lasting character than that derived from the difficulties of beer.

Reference has been made frequently during recent years to the striking increase in consumption of cider. In the absence of authoritative statistics the accuracy of this assertion cannot be checked. It may be true, but certainly to a notable extent the alleged increase is apparent rather than real. The output from the factories undoubtedly shows a considerable expansion. In addition, many breweries have taken up cider-making within recent years, and some are very large producers. On the other hand, an increasingly large number of farmers now sell their apples to the factories instead of making cider themselves for purely local consumption and much less cider is drunk on the farms. What has been happening is that the use of cider is more in the public eye because the general public is consuming more and the farm labourer

less. A safer and probably more accurate way of expressing the position is that the total value of cider sales now is considerably greater than in pre-war days.

It is assumed by some that the imports of cider apples and cider from overseas, and from France in particular, are evidence of increased consumption of the beverage in this country; it can be claimed on the other side that such importations are merely evidence of the decreasing crops in the farm orchards of the western counties.

The aged and decrepit state of a seriously large percentage of the existing orchards is a matter of common knowledge. Apart from the normal losses in trees in such orchards from old age and the ravages of disease, every severe gale that sweeps the West Country leaves a trail of uprooted trees. A few years ago, after one particularly heavy storm, the writer during the course of a tour in Devon passed orchard after orchard with from 25 to 50 per cent. of the trees lying prone on the ground.

To counterbalance the loss of crops from these casualties there is little to contribute in the form of increasing crops from a younger generation of cider orchards. For at least a generation before the end of the war the planting of cider apple trees was, if not actually negligible, at least on so small a scale as to be entirely inadequate to replace the natural losses among the older trees. About the war period and immediately afterwards a large proportion of the trees planted were of table varieties of apple, and not infrequently the heads of suitable established trees of cider apples were cut off and regrafting with table varieties carried out.

Since the war the improved position of the cider industry and the greatly increased prices for cider fruit prevailing—the National Association of Cider Makers has recently given a 5 years price guarantee of a minimum of £4 per ton—have encouraged the planting of new cider orchards and this movement, slow at first in getting under way, is now approaching considerable dimensions. Some of the larger firms of cider-makers have acquired land and are establishing new orchards to serve their own requirements. One well-known firm has undertaken the raising of young trees of some of the best cider varieties in its own nurseries and has offered them to farmers on attractive terms. It alone has distributed over 50,000 young trees in the county of Hereford within the last five years, which is equivalent to an increase of about 1,000 acres in the area of cider orcharding. A still more recent development, on novel lines, has been started during the present planting season by the Federation of Devon Cider-makers. For every ton of fruit

sent into the factories of members of the Federation a cider tree is being given without charge to the farmer supplying the fruit. Through this means this season there are being added to the Devon orchards not less than 15,000 trees. To these efforts directly arising from the firms engaged in the industry must be added the unorganised plantings being carried out by individual farmers. In fact the re-establishment of the cider orchard system in this country may be regarded as now being in active progress.

There is nevertheless a great task still ahead before there is recovered the leeway of 30,000 acres, which the writer estimates to be the minimum amount required in the form of new orchards to make good the existing deficiency and meet the needs of the immediate future. Also it must not be forgotten that in respect of output of cider these new plantings will not affect the situation materially until at least some fifteen to twenty years hence. That time is required for the trees to grow to a size sufficient to produce crops that count.

For immediate needs for fruit the present deficiency of the home supplies of cider fruit is being met, as already stated, by imports of fruit and cider from overseas. In addition, the ungradable apples, or "culls" as they are commonly termed, from the commercial table apple plantations and orchards in this country are being utilised extensively. Marketing methods in the disposal of the home-grown table apple crop have been revolutionised during the last few years, the change having been accelerated by the introduction of the National Mark Scheme. Grading has become essential and the bulk of the crop falling below the recognised market grades is withheld from the fresh fruit market. Much of it is now being regularly absorbed by the cider industry. It is true that according to the old ideas, and in the opinion of those accustomed to typical West Country cider, such material is not suited for the production of a high quality cider. Generally speaking, used by itself it is not; but research has demonstrated that by blending it with suitable kinds of true cider apples a useful commercial cider can be made. The latter has established itself firmly in the favour of a vast number of new consumers of cider which the modern development of the industry has created.

To attract and hold the new class of cider drinkers a considerable degree of standardisation of the beverage has been enforced upon makers. No commercial article in these days can hope to establish itself and maintain a continuous demand unless the uniformity of the brand can be relied upon. For each maker it is imperative that each of his series of blends or brands should be distinctive and

reasonably constant in character, if he is to secure regular success. Large bulks of individual blends are thus called for, and careful and scientific blending has become a necessity. To many of the old school of cider drinkers this appears a retrograde development, for the occasional ciders of superlative quality which from time to time are produced are necessarily of relatively small bulk, and are inevitably graded downwards in quality by inclusion in a much larger blend. This disadvantage, however, has to be considered under modern commercial conditions as more than outweighed by the advantages of standardisation.

A recent move designed to ensure the consumer an article of standard and guaranteed quality is the establishment of a National Mark Scheme for cider. Brands bearing the National Mark are guaranteed to be made exclusively from fruit grown in this country and under approved conditions: in addition they have to conform with the standards specified under the Scheme.

Looking to the future in relation to the admitted drawback of standardisation as stabilising a grade which represents not the highest quality obtainable, but an average possible under existing commercial conditions, the soundest policy seems to be to aim at attaining by degrees improvement in quality under standardisation by growing in the orchards established in future only varieties of the highest grade. By that method the present miscellaneous collection of sorts which tends to keep the average quality low will be gradually eliminated.

THE PROVISION OF SUPPLIES OF VINTAGE FRUIT.

Having reviewed the principal features of the course of development of the cider industry during recent years, their general bearing upon the character and quantity of the supply of apples likely to be needed for its purposes in the future and, consequently, upon the nature of the new cider orchards required can now be considered.

Firstly, since the beverage produced must conform in type to the public taste and since to a large extent a new public for it with leanings towards a modernised and standardised form has been created, the character and blend of the apples utilised in its manufacture need to be selected accordingly. It has to be recognised that the kind of cider wanted by the average consumer in districts outside the producing areas is a very different article to the traditional West Country cider. The very rich and potent full-bodied old-fashioned ciders with definite bittersweet character do not seem to make the same appeal to the man in the street as the

lighter, less alcoholic, medium sweet and brisk types which have come to the fore so much in recent years. The modern technique of cider making has certainly had some tendency to bring this type to the fore, but the proportions of the different classes and kinds of apples utilised also have been closely concerned.

Secondly, for a long period ahead—perhaps permanently—the cider industry will be obliged to absorb a large proportion of the “culls” of the eating apple crop. Formerly many of these went to the jam factories, together with a large proportion of the so-called “pot” varieties of our farm orchards. That outlet has diminished greatly during recent years, since the introduction of pectin extracts to ensure the proper setting of jams has caused a heavy falling off in the demand for such apples, which hitherto had fulfilled that function.

Thirdly, to produce suitable commercial ciders under conditions which involve the use of a relatively large proportion of “cull” apples, it is necessary to have available for blending purposes an adequate supply of true vintage apples of the low-acid types, *i.e.* varieties belonging to the sweet and bittersweet classes. The cider made exclusively from cull apples is characterised by two outstanding disadvantages:—(a) too much acidity, due to the high content of malic acid in such apples, and (b) too little body and character, resulting largely from the very small amounts of the “tannins” and related compounds present in those apples. Thus, to counteract those weaknesses in quality, blending with kinds possessing the directly opposite characters, chemically, is required.

The bittersweet type of apple with its very low acidity and high tannin content provides the necessary balance in both respects. Supplies of this type in appropriate quantity are essential for the most satisfactory results. But apples of the “sweet” class also are indispensable, although not required in the same quantity. With the “cull” apples providing the needed acidity there is no longer the room for apples of the “sharp” or “acid” vintage class that there used to be before “cull” apples entered seriously into cider-making. For ciders of the highest grade they remain as essential as they have always been, and for that reason it cannot be advised that they should be ousted completely from the vintage orchards of the future. No culinary apple could be an adequate substitute for a Frederick, a Cap of Liberty or a Foxwhelp, for example, in a cider blend designed to typify the beverage at its best: but for everyday purposes of bulk production of cider their place could be taken by “cull” Bramley’s Seedling apples or any other of the usual culinary commercial varieties without any obvious detrimental effect on the public demand for the drink, or, probably, on the

maker's profits. There remains the case of the Kingston Black and the very few other vintage varieties, which in suitable years yield ciders of the highest bottling grade unblended, and in others call for but a very small admixture of other sorts to produce a beverage of first-class standard. The members of this select group command at present—and seem likely to do so in future—a special price of their own. For these aristocrats among vintage apple varieties there should be always a place, although the extent to which their planting can be advised needs careful thought, since few, if any, make satisfactory orchard trees, except under conditions specially suited to them.

Fourthly, the production of ciders in bulk conforming in standards and uniformity to the requirements of public taste demands a drastic change in present orchard conditions in two respects, if the maker's task is to be achieved in a scientific and reasonably simple manner. The haphazard and extensive collection of heterogenous sorts of apples to be found in most of the existing orchards in bearing must be replaced in the orchards of the future by groups of varieties as limited in number as far as the circumstances of the case will allow, with each variety of a high grade of merit from both orchard and vintage points of view. "The best varieties only and as few of them as possible" must be a guiding principle in future orchard planting.

Also a radical improvement in the methods of harvesting the fruit is required. Far too often the fruit is collected indiscriminately and is passed on to the factory as a miscellaneous mixture both of sorts and degree of ripeness.

Fifthly, the industry must be prepared as quickly as possible to produce in this country the whole of the fruit needed for its requirements. It has been fortunate so far in being able to import fruit for cider production free from any duties under the new tariff regulations except the standard 10/- per ton duty levied on all imported material. All other imported apples are subject to a tariff of £4 10s. per ton. This preferential treatment has been secured on the strength of the fact that the home supply of fruit is inadequate for the time being to meet the demand for cider purposes. It is understood, however, that such preference cannot be continued permanently: it has been granted solely as a temporary measure, while the industry is setting its house in order in the matter of home supplies. A duty charge at the same rate as that for other imported apples would make the price of cider practically prohibitive and the industry must recognise, therefore, that it has to face what amounts to a practically compulsory obligation to speed up the home production of apples for cider-making until demand and supply are balanced.

Sixthly, even assuming that the planting of cider fruit in the orthodox fashion is proceeded with immediately on the necessary scale, many years must elapse before these new plantings become really effective in bringing the total crop to the size required. Consideration should be given on that account to possible methods by which increased crops might be obtained more quickly. There are two ways by which this object could be achieved, viz. by improving the health and cropping capacity of existing orchards by appropriate spraying and manurial treatment, and by establishing new plantations of cider fruit on modern lines designed for quick crop production. The former method has been tested during the last few years with highly encouraging results and appears likely to be widely adopted. It is known already that the latter method can be applied to cider fruit, but at present its economic aspect is uncertain. This is being investigated as rapidly as possible.

THE CHARACTER AND ESTABLISHMENT OF YOUNG CIDER ORCHARDS.

These, then, are the considerations which have to be borne in mind by intending growers of cider fruit, and the following recommendations on the character and planting of cider orchards are made after taking them into account. There is an obvious difficulty in formulating proposals to apply to orchards which cannot in the nature of things become effective crop producers until some twenty years or so ahead and which under favourable conditions should have a lifetime of about a century. Conditions and needs may have changed radically even before the profitable bearing stage is reached. It is desirable accordingly to plan so as to give the greatest possible elasticity of modification of crop or system, in case circumstances should render changes desirable after the orchard is established. Fortunately the grower is not committed irrevocably to his original choice of varieties, for the trees can be top-grafted with other sorts well into middle life at least, provided that they are cared for reasonably. Also, if a change from cider fruit to eating apples should become advisable under changed conditions of demand or other circumstances, the cultural conditions of the orchard can be changed from grass to arable or to any intermediate form of culture that may be required to yield a sufficiently high grade of fruit.

The primary problem always confronting an intending grower at the outset is the production of remunerative crops. It follows that his choice of varieties to grow must be based ultimately upon their orchard qualities. Whatever their vintage qualities, the

sorts selected must be capable of producing a reasonably large and healthy tree under his conditions and crops which will pay adequately. At the same time, since the orchard is being established to provide fruit for cider-making, the chosen sorts must be kinds wanted by the cider maker and the orchard arrangements should be such that the fruit can be delivered to the factory in the form and condition most useful to the maker, if the best prices are to be realised.

Orchard management in the cultural season also calls for consideration. An orchard comprised of varieties ripening at different periods covering the whole of the autumn season has to be closed against grazing for two or three months if the fruit is to be harvested in cleanly condition. Long before the end of that time the grass has grown to such an extent that the collection of the fallen fruit is hampered and satisfactory grazing down of the coarse herbage is difficult.

This point of approximate simultaneous ripening of the crops of individual trees in an orchard is actually of far greater importance to the cider maker than to the fruit grower himself. Lack of observance of it in the planting of the existing orchards has probably been more responsible for the production of cider of inferior quality than any other single factor. The temptation to many growers to clear their orchard crops completely once they have started fruit harvesting operations is too great to be resisted, with the result that the fruit is delivered to the cider house in the worst possible condition from the vintage point of view. Hard unripe apples are mixed up with over-ripe sorts and others on the point of ripening. Such a mixture cannot be stored sufficiently long to mature properly and generally by the time the maker can deal with it decay is spreading fast through the heap. This, probably the commonest and the greatest difficulty of the cider maker, would automatically be almost eliminated if orchards were planned to contain exclusively only early, mid-season or late ripening varieties respectively. With so large a collection of excellent sorts of each ripening season available for selection any other course must be strongly deprecated for any but special cases.

Taking into account the bearing of the various points in the foregoing discussion on the character of the cider orchards needed to serve the future requirements of the industry, as far as can be foreseen from the present tendency of events, the following conclusions present themselves.

1. The number of varieties grown in an orchard should be reduced to the smallest possible number consistent with

the pomological needs for the satisfactory pollination and setting of the crops and for the reasonable chance of a crop every year to provide against the crop failure of any particular variety in a season unfavourable to it.

2. The total number of varieties grown in the orchards as a whole should be restricted as far as possible, taking into account the suitability or unsuitability of individual varieties for particular districts.

Only by the general adoption of the course indicated in the preceding paragraphs can the industry be assured of securing a bulk supply of fruit of reasonably uniform and known character.

3. The varieties grown in an individual orchard should produce fruit ripening at approximately the same time in the autumn. This will permit the concurrent harvesting of the individual sorts present and will allow them to be kept separate, where this is desired.
4. The choice of sorts should be limited mainly, for some years to come at least, to varieties belonging to either the bittersweet or the sweet class—the former preferably—except in special cases of the few outstanding vintage varieties like the Kingston Black and Foxwhelp.
5. As a general rule no variety should be selected for planting which does not combine a high degree of orchard merit with good vintage quality.
6. When the production of low-acid apples of the bittersweet and sweet classes on a scale sufficient to meet the blending requirements of the cull fruit supplies of this country which must be absorbed by the cider industry has been achieved, the planting of the better of the true vintage varieties of the sharp class, such as Frederick, in combination with suitably proportioned numbers of trees of the low-acid types could be recommended with advantage to the general quality of cider. In the meantime steps should be taken to prevent the risk of the pick of these sharp vintage varieties dying out.

Action along these lines should do much to bring the home-grown supplies of cider fruit into line with the requirements of the industry, provided that orchard planting is proceeded with energetically. It would not solve all problems, because there is at present a lack of close co-ordination between the fruit grower and the cider maker. The latter, for example, wants a steady supply of

fruit coming into the factory continuously from September until the end of the year—in some cases even later. The prospective grower at the moment has no lead as to what period of that season he should cater for in his new plantings and it may well happen that without guidance from the maker his efforts will result in the factories being glutted with fruit during part of the making period and short of supplies during the remainder. Many other instances of the need of co-ordination might be instanced.

The interests of the growers and the makers meet at a common point in this matter of fruit supplies. It is fundamental for both parties. Is it not time that a joint representative body should be established as a permanent Council to secure the necessary degree of co-ordination? With the National Farmers' Union now in a position to speak representatively of the great majority of cider fruit growers—it has recently established a Cider Sub-Committee of its own—and the National Association of Cider Makers equally well placed in respect of the commercial cider makers, it should not be impossible to establish an influential Council such as that visualised to provide guidance on so important a matter for both sections. The germ of this movement is stirring: properly fostered it could render both sides of the industry incalculable service.

Passing on now to the details of the planning, establishment, and care of new orchards, it may be observed at the outset that established local practice varies somewhat in different districts, past experience having indicated modifications from normal methods to suit local conditions. The following observations must of necessity be general in character and should be regarded as open to modification in particular cases where local circumstances require.

Soil and Site.

The grower is usually restricted in these respects, but where choice is possible some guidance can be given.

Recent research on the subject of soil in relation to fruit culture has shown that apple trees can be grown successfully on a far greater variety of soils than was considered possible previously. In fact, with appropriate management good results can be obtained on most soils provided that the land is well drained, either naturally or by the provision of an efficient drainage system. The most frequent natural cause of failure is inefficient drainage, since healthy trees cannot be produced under conditions where the root system is liable to waterlogging.

At the same time the type of soil has a distinct influence upon the quality of the cider produced from the fruit grown upon it. It is generally agreed that the richest ciders are produced from orchards on soils of a somewhat heavy and retentive character. Where soils favour quick tree growth, the resulting ciders tend to be thin and coarse. The question of the nitrogenous nutrition of the tree is certainly involved in this connection, for the quality of a cider is closely associated with the nitrogen content of the juice from which it is made. Juices containing relatively large amounts of organic nitrogen ferment more quickly and give a thinner, coarser product than those with less nitrogen. Thus not only soil conditions but orchard management and manurial treatment have a direct bearing upon cider quality through their effects on the nitrogenous state of the trees and should be taken into account when considering the apparent effects of soil upon cider quality.

Several of the best varieties of apples from the vintage point of view are very subject to canker. It is a fortunate fact that, generally speaking, the soils associated with slow tree growth and high cider quality produce a type of tree apparently offering the greatest resistance to canker.

In this country there is one other feature concerned with the soil which can play a determining part in the success or failure of an orchard. That is the natural available potash content. With a potash deficiency, or an unsatisfactory potash-nitrogen ratio, the trees are doomed to failure in arable orchards, however satisfactory the soil conditions in other respects may be. Leaf scorch occurs, growth is completely stunted and ultimately death ensues. In grass orchards the ill-effect is greatly reduced, probably owing to the effect of the grass in keeping the potash-nitrogen ratio at a more satisfactory figure through the overmastering call of the grass on the nitrogen present, but even so manuring with sulphate of potash is advised. In the case of arable orchards it is imperative.

As regards selection of a site, where choice is possible, locations subject to late spring frosts should be avoided on account of the risk of injury to the blossom at flowering time. A sunny aspect, especially one catching the morning sun, is advantageous because of the value of sunshine in developing fruit quality and favouring fruit bud formation. A slightly sloping position is also desirable, since efficient drainage is facilitated. Windswept sites involve risks of tree and crop damage.

Trees for Planting.

The question of varieties to plant is being considered separately later.

The question of the type of tree suitable for planting has been much debated in the past and considerable difference of opinion still exists.

It is agreed that for grass orchard purposes the main stem of the tree must be sufficiently long to prevent damage by stock grazing in the orchards. At the same time, if the site is exposed and subject to heavy gales, a tall-stemmed tree feels the effects more than one with a shorter stem. Thus local conditions should largely govern the choice. Throughout the greater part of the West of England standard trees with a length of main stem not less than $6\frac{1}{2}$ feet to the lowest branches of the head are favoured, since that permits the orchard to be grazed by cattle. For wind-swept districts and on steeply sloping sites, such as are commonly found in Devon, a tree more nearly approaching the half-standard type with a main stem not exceeding 6 feet in length is preferred. Grazing in such orchards has to be limited to sheep and young stock, and possibly pigs in special circumstances.

The subject of the age of the tree for planting is more controversial. It may be accepted that the younger the tree when transplanted from nursery to orchard the less is the shock of removal and the more rapid the recovery from the check. On the other hand, the younger tree may require more careful staking and protection against grazing stock over a longer period of years than an older one, although this is not invariably the case owing to the more rapid recovery from the planting check on the part of the former. Taking everything into account, probably the most satisfactory choice in the average case is a well-grown 4-year-old tree, *i.e.* with 4 years growth from the time of grafting or budding, after being pruned in the nursery when 2 years old to form the head. The practice, prevalent in some districts, of planting large trees with stout stems some 7 or 8 years old is usually condemned by most modern authorities on the ground that the transplantation check is so excessive that recovery is seriously retarded, the future well-being of the tree prejudiced, and the period of protection required not less than in the case of a younger tree.

A point on which there is room for difference of opinion is that of the time when the tree should be worked with the cider variety selected. The case is not parallel with that of the eating variety of apple, where the normal practice is to bud or graft the desired

sort direct on to the rootstock a few inches above ground level. For grass orchard purposes a standard tree with a clean straight and well-formed stem some $6\frac{1}{2}$ feet in length is needed, as already mentioned. Some of the best cider varieties are not vigorous enough in growth to produce a stem of that description without at least an extra year in the nursery quarters. Even then a satisfactory result is doubtful. To save this loss of time and additional cost the practice of double-working, *i.e.* grafting any suitable strong-growing variety direct on to the rootstock, allowing this to form a stem of the desired character and then top-grafting this in turn with the permanent cider variety to be grown, is being increasingly adopted. The chief point at issue then is whether or not the re-working with the ultimate variety should be done during the nursery life of the tree or after the latter is planted out in the orchard. The question has not yet been finally settled by experiment and a definite answer is hardly urgent. Satisfactory trees can be grown under either method. Since for some time to come the total number of trees available for planting may not be equal to the demand, it is suggested that for the time being the prospective grower should secure the best trees procurable irrespective of variety and top graft them with the desired kinds after planting, if necessary.

As regards the kind of rootstock upon which the tree should be established, there are three classes to consider, *viz.* (a) "crab" stocks, *i.e.*, seedlings raised from the seed of "crab" apples; (b) "free" stocks, *i.e.* seedlings grown from miscellaneous apple seed, mostly obtained from the pomace of French cider apples; and (c) "layered" stocks, *i.e.*, plants propagated by the vegetative methods of "layering" or "stooling" from selected strong-growing stocks of known character. Every seedling stock is necessarily a different sort and the "layered" stock has the advantage of uniformity with the particular kind selected. Against this advantage must be set the important disadvantage of ignorance as to the prospective duration of life of a standard tree worked upon a stock of this kind. No trials have been in existence long enough to justify anyone dogmatising on this point. In view of the length of life expected from a cider orchard it is safer to adhere for the present to the older seedling stock usage. The great majority of standard trees raised in the nurseries are on the seedling "free" stocks, and it would be difficult probably to obtain supplies on genuine "crab" stocks now. Some of the older school of orchardists are emphatic as to the superiority of "crab" over "free" stocks, claiming for them the production of longer lived and hardier trees. Their view may be correct, but in the absence of any critical experiments of long-standing duration their case rests upon personal observation of a general character over many years on material which the

modern scientist would not be prepared to accept as suitable for strict comparison.

Orchard Planning and Planting.

Ideas as to the lay-out of the orchard have tended to change recently. Hitherto it has been customary to plant the trees in parallel rows, so spaced that each tree stands about 30 feet apart from its neighbours in each direction. That arrangement gives what has been termed the "equilateral triangle" system of positioning and allows the maximum number of trees possible to be planted on the site with equal spacing for each. The system now finding increasing favour is to plant the rows wider apart (36 feet) with the trees equidistant at about 30 feet apart in the rows, each standing immediately opposite to the corresponding tree in the rows on either side, giving a "rectangular" system of positioning. Although this plan carries fewer trees to the acre, it permits more light and air to each tree, an important point for crop yield and vintage quality, and also renders the herbage more valuable for grazing. On poorer land or under typical Devon conditions the distances could be reduced to 30 feet between the rows with the trees 27 feet apart in the rows.

The details relating to the planting, staking, and protection of the trees may be found in various leaflets and pamphlets on Farm Orchards issued by several of the County Council Agricultural Education Departments in the West of England, and thus need not be repeated here in full. They can be obtained from the Agricultural Organiser of the County in which the applicant is resident. The details may be summarised briefly as follows.

The holes dug for the trees should not be less than 4 feet in diameter and dug to a depth of about 1 foot. The subsoil at the bottom of the holes should be broken by forking to the depth of another foot. Before the tree is planted the supporting stakes should be inserted firmly in the holes. A single stake for each tree will suffice. It should be preferably a post of creosoted deal or larch, about 3 inches square in cross section, and 8 feet in length after being pointed for insertion in the soil. The tree is then planted with its stem close to and on the leeward side of the stake, with sufficient space left between to permit of the subsequent growth in girth without rubbing during the period the tree requires staking. In tying the tree to the stake the use of tarred cord, wire, binder twine and sacking should be avoided. It is advised that the netting which is placed around the tree and the stake, to which it is fastened, should not be less stout than that of 16 gauge and $1\frac{1}{4}$ inch mesh. The tree should be planted firmly, the topmost roots being

covered with about 3 inches depth of soil. The top spit of turf, which should be removed separately and placed on one side when digging the holes, should be broken up into small pieces and placed over, *not under*, the roots at the time of planting. For at least two or three years after planting it is beneficial to the tree to keep the soil at the surface of the planting hole free from weeds and for the first year a mulch of farmyard manure may be found advantageous in the event of a period of drought before the new root system of the tree is properly developed.

Treatment after Planting.

It is not proposed to deal here with those matters of after-care of the young trees which are common to both cider and table apple orchards. The purpose being to consider the production of cider fruit, attention will be directed only to those features in which the treatment is distinctive.

In respect of pruning, after the shaping of the head of the young tree has been satisfactorily achieved, little pruning is necessary subsequently beyond the removal of intercrossing or damaged branches, since the objective is the production of heavy crops rather than of marketable-sized fruits.

Treatment for disease and pest control has to be viewed from an angle radically different from that obtaining in the case of market apples. The value of vintage fruit is so much lower than that of the latter that costs of production must be kept correspondingly low. A heavy spraying bill cannot be faced. Until recently a cider orchard was rarely sprayed. A succession of bad cropping seasons in the cider orchards of the West Country, however, has recently caused investigation to be made to determine if the crop failures were due largely to pest and disease ravages and, if so, whether they could be avoided or reduced by appropriate spraying treatment. Experience during the last few years has demonstrated that in the older existing orchards particularly a marked improvement in crop production can be obtained by spraying. In many cases it has yielded fair to good crops in place of probable total crop failure and the results have been so decisive as to leave no doubt as to spraying being the cause, and to enforce the conclusion that a striking increase in cider fruit production in this country could be secured immediately by this means.

These spraying investigations have not been in progress long enough yet to justify the recommendation of a comprehensive spraying programme. Thus far the effects of a single winter spraying with a modern type of tar-oil egg-killing winter wash against insect

pests generally and a single spring spraying with dilute lime-sulphur against scab and other fungous diseases have been tested separately. In each case the spraying has proved a paying proposition. Whether it would be an economic success to carry out both in the same orchard in any one year remains to be proven. A more ambitious programme still must be deferred for consideration until the previous question has been settled.

Lack of spraying equipment need no longer be a bar against spraying, since it is now possible to get the work done under contract arrangements with various firms or individuals. In Herefordshire the County Council has available an up-to-date machine, recently presented to it for County use by a leading firm of cider makers. The removal of the difficulty of the spraying tackle ought to facilitate a great increase in farm orchard spraying. Those growers who have tried it during the past two years appear highly satisfied with the results.

Any desiring fuller information on this subject will find an account of the recent work in the Annual Report of this Station for 1932. On application to the Station they can obtain supplementary particulars and also information on the complex subject of manurial treatments which would occupy too much space to discuss here.

QUICK PRODUCTION METHODS FOR CIDER FRUIT.

The foregoing remarks on the establishment of new orchards apply to the production of cider fruit in the normal way in grass orchards. It was mentioned earlier that this method is slow in relation to the pressing need of the times for home-grown fruit, and that quicker production was possible by the adoption of more modern methods. The latter methods in view are in principle similar to those used in commercial apple culture with modifications suited to the particular case of vintage apples. They consist in growing the trees in a dwarfed form as half-standards or bushes, suitable rootstocks of the dwarfing or semi-dwarfing types being used to restrict the size of the trees and bring them into cropping quickly. With the closer planting possible for this smaller type of tree a substantial crop yield per acre can be obtained in the course of a few years. This form of plantation must be kept under arable conditions until the trees have nearly filled the spaces allocated to them: subsequently they may be grassed down and their nutritional requirements controlled by the application of artificial manures. Hitherto only a few tentative trials of cider

fruit culture along these lines have been made, and no conclusions as to the economic aspects are possible at present. The Long Ashton Research Station has recently made provision for an exhaustive series of trials over a wide area, and the results of these should decide whether or not quick production of cider fruit in this manner is economically practicable and also satisfactory from the vintage point of view.

Another method of accelerating cider fruit production which has been adopted by some commercial growers recently is that of head-grafting established orchard trees of other kinds of apples with cider varieties. In the space of a few years the regrafted trees make sufficient growth to provide fair crops of fruit and do not require much longer before the full cropping stage is reached. The method has been taken up by commercial growers in the chief fruit districts of the country outside the West of England to assist the disposal of their "cull" apples. In such cases only sweet and bittersweet varieties have been grafted and for the most part the trees selected for regrafting have been of kinds of market apples which have now dropped out of favour or have proved unsatisfactory in the orchards concerned.

SELECTION OF VARIETIES.

Finally there remains for consideration the individual varieties of apples which can be recommended for culture as conforming with modern requirements. With so large a number as still exist in English cider orchards it is not possible to write authoritatively of the vintage merits of more than a fraction, and of the combined vintage and orchard merits of still fewer. Much detailed information on the subject has been published in the Annual Reports of this Station: nevertheless any list of selected varieties must be open to criticism and must certainly be subject to modification from time to time as further knowledge accumulates.

To obtain as representative a list as possible a joint conference of representatives of the Western Counties branches of the National Farmers' Union, the National Association of Cidermakers, and the Long Ashton Research Station met early in 1932, and selected the following varieties to recommend for culture:—

SHARP.	SWEET.	BITTERSWEET.
Crimson King.	Eggletton Styre.	Bulmer's Norman
Dymock Red.	Sweet Alford.	(syn. White Muscadet).
Fair Maid of Devon.	Woodbine II	Dabinett.
Reinette Obry.	(syn. Slack ma Girdle).	Ellis' Bitter.
		Knotted Kernel.
		Royal Wilding.

HIGH GRADE VINTAGE VARIETIES.

(The varieties of this class are subject to canker,
but can produce satisfactory trees where local
conditions are suitable.)

Cap of Liberty.

Foxwhelp.

Kingston Black.

The above list is incomplete in that it does not include varieties to cover the whole season of cider making. The accompanying supplementary list is therefore suggested by the writer to fill the gaps and to offer a slightly extended range of choice to meet some of the needs of different localities.

<i>Cider Apples.</i>	<i>Sharp.</i>	<i>Sweet.</i>	<i>Bittersweet.</i>
Early (to mid-October)	Backwell Red	Court Royal White Jersey	Belle Norman (syn. Perthyrres) Major
Mid-Season (mid-October to end November)	Langworthy Stoke Red Yellow Styre	Woodbine I (syn. Sweet Woodbine)	Tremlett's Bitter White Close Pippin Yarlington Mill
Late.	Frederick	Thomas Hunt	Chisel Jersey Medaille d'Or II Michelin Reine de Pommes Silver Cup Tardive Forestier
Perry Pears.	— —	Butt Oldfield	— —

It will be observed that the above lists include varieties of the sharp class and also the few sorts of outstanding vintage quality in addition to sweet and bittersweet kinds. Attention has already been drawn in the course of this article to the importance of having a predominant supply of fruit of the latter types. The others are included in the lists in the hope and belief that there will always be some demand for a cider of the highest possible grade of quality, even although its price may be high in comparison with that of the "popular" brands.

For the benefit of those wishing to grow not more than three or four varieties, and desiring some guidance as to choice from the above lists, it may be stated that general experience has shown

Sweet Alford and Dabinett to be as reliable as any and to be specially well suited to meet the needs of the present and near future for fruit of the low-acid classes. Knotted Kernel also is an exceptionally valuable variety but is very slow in coming into bearing, although a heavy cropper when that stage is reached.

In the course of this article no specific reference has been made to the growing of perry pears. Perry as a beverage is little known outside the producing district of Hereford and the adjacent counties, and there are very few interested in the question of planting new perry orchards. A first quality perry is, however, so fine a drink that it must be hoped that its production will not cease when the existing orchards disappear. The inclusion of the two varieties of perry pears in the above lists has been made for guidance to any who may be prepared to plant a few perry trees. The two sorts named are particularly valuable for vintage quality.

In conclusion, it can be claimed for cider fruit that during the difficult post-war years the farmer has found his orchards highly remunerative, since the recent development of the industry has successfully maintained the enhanced prices for the fruit which resulted during the war. The culture of table apples may yield considerably higher profits, but those are associated with greater risks owing to the much heavier annual expenditure on cultural treatment. As far as can be foreseen cider fruit growing appears to be likely to give steady but moderate profits for a relatively low capital outlay and annual expenditure, and with comparatively little attention and work associated.

BIENNIAL BEARING OF APPLE TREES.

I. BLOSSOMING AND FRUITING OF INDIVIDUAL SPURS.

II. THE EFFECT OF BLOSSOM AND FRUIT THINNING.

By THOMAS SWARBRICK.

INTRODUCTION.

Biennial bearing presents a serious problem in some apple varieties, whereas in others it is almost unknown except in isolated cases. The regularity with which mature trees of varieties like Early Victoria bear in alternate years has given rise to the idea that, in certain varieties, the phenomenon is inevitable. This may or may not be true, but in any case it is the experience of both growers and experimenters alike, that once trees have become established in the biennial bearing condition, the habit is difficult to eradicate.

In order to prevent the onset of biennial bearing and to correct it once it has become established, it is necessary to understand how trees develop into such a condition. In this connection answers are being sought at Long Ashton to two major questions: (a) How do trees get into such a condition where they only carry an economic crop once every two years, and (b) Given a tree in this condition, how can annual cropping be re-established. The problems are being attacked both from the purely physiological and the practical aspects.

The first of these two questions is being examined by conducting a detailed study of the bearing habits of individual spurs on two varieties of trees, one a biennial bearer, Lane's Prince Albert, and the other an annual cropper, Worcester Pearmain. In this way it was hoped to obtain more precise information concerning the fruiting performance of individual spurs.

As regards the second problem, that of correcting biennial bearing, this is being directly attacked by a series of blossom and fruit thinning experiments on the variety Early Victoria.

The data obtained in these two phases of the investigations are presented separately in the present paper.

I. BLOSSOMING AND FRUITING OF INDIVIDUAL SPURS OF LANE'S PRINCE ALBERT AND WORCESTER PEARMAIN.

From observations made by horticultural investigators in the past, the general conclusion has been reached that in most apple varieties successive year *bearing* of spurs is comparatively rare, although successive *blossoming* may be quite common. Spurs which blossom and carry fruits to maturity in any one year rarely blossom the next; though others which blossom but do not set fruit in a given season may quite often blossom again the following spring, and may even carry fruit to maturity. It would seem therefore that individual spurs are biennial in fruiting habit.

With these observations in mind, about 200 spurs on a fifteen year old tree of Lane's Prince Albert upon the vegetatively raised rootstock Malling No. I, were separately labelled and numbered in the spring of 1928. In a similar way spurs of a tree of Worcester Pearmain of the same age and upon the same stock were also labelled. A detailed history of these spurs has been kept by making observations at the blossoming time, immediately after "fruit set" but before "June drop," and finally just before harvest. The records at present under review cover the period from the spring of 1928 to the harvest of 1929.

Four to five year old branches were selected for labelling and all spurs or growths upon these branches were labelled and numbered. In this way errors due to selection of material were reduced to a minimum and all kinds of spurs were under observation. This latter point is important, since the two varieties have widely different fruiting habits.

The variety Lane's Prince Albert is not the worst of our English varieties for falling into the biennial condition, but was the most suitable variety available. It is, by contrast with Worcester Pearmain, a variety which bears its fruits almost entirely upon spurs. Flower buds in this variety consequently take two years to develop. Once formed, the spurs do not often develop vigorous new shoots from their bourses, but continue their growth each year by means of short bourse shoots. The trees are eventually clothed with masses of short spurs which give the tree a characteristic appearance in winter.

Worcester Pearmain is a variety which under normal conditions fruits extensively at the tips of short, one year old shoots. Growths of three to eight inches long or even more are almost invariably

terminated by blossom buds and, while on the older parts of the tree typical short spurs may develop, in practice the main part of the crop is produced on the ends of short, one year old shoots. Furthermore, Worcester Pearmain is generally recognised to be a regular cropper, and is rarely found in a biennially bearing condition. The regular bearing of this variety appears to follow naturally from the fact that it fruits at the ends of short one year old branches, because so long as the trees have sufficient vigour to produce a crop of short shoots in any one year, a crop of blossoms is assured for the following spring.

Considering first the typical spur bearing variety, Lane's Prince Albert, a record was kept of 60 spurs that were "vegetative" in the spring of 1928 when the observations were started. Of these 60 "vegetative" spurs of 1928, 37 of them (or 61%) were "flowering" spurs in spring 1929, of which 27% carried fruits to maturity in the autumn of 1929. Field notes taken in spring 1928 indicate quite clearly that it was the vigorous "vegetative" spurs of 1928 that developed into the "flowering" spurs of 1929. These spurs were, in fact, almost invariably situated upon the two and three year old branches, and were therefore flowering for the first or second time. On the other hand, the spurs which were "vegetative" throughout the years 1928 and 1929 were invariably the weak spurs, and were found almost entirely in shaded positions and on the older branches. It is evident from these observations that the age, position, and vigour of a spur materially affects its performance. The young vigorous "vegetative" spurs of one year show a stronger tendency to become the "flowering" spurs of the following year than do the weaker spurs.

In the spring of 1928, 86 spurs of Lane's Prince Albert were labelled as "flowering." These spurs were on the same branches as the "vegetative" spurs referred to in the previous paragraph and were in fact intermingled with them. Of these "flowering" spurs of spring 1928, 22% of them carried fruits to maturity in the autumn, and not a single one of these latter spurs blossomed again in spring 1929. Of the remaining 67 spurs which blossomed in spring 1928, but did not carry a fruit beyond the "June Drop," eight of them blossomed again in spring 1929, and three "set" fruits.

It appears from the foregoing observations that there was a fairly uniform distribution of "flowering" and "vegetative" spurs on the trees under observation. It was found that the "vegetative" spurs of one year showed a strong tendency to become the "flowering" spurs of the following year. This tendency was most marked in the more vigorous and younger spurs. The

weak and older spurs showed a strong tendency to remain "vegetative" during two or more successive years. It was also noted that spurs which "flower" in any one year tend strongly to remain "vegetative" during the following year, since only 12% of the spurs which flowered in 1928 but did not set fruit flowered again in 1929. In the present study not a single spur which "fruited" in 1928 was observed to "flower" in 1929. It must not be concluded, however, that a spur cannot fruit one year and flower again the following year. Careful observations suggest that under certain growing conditions this may take place, but that it is not usual, at least so far as "spur bearing" varieties are concerned.

It is concluded from these observations upon the spur performance of Lane's Prince Albert, that the individual spurs of this variety exhibit a marked biennial tendency. The "vegetative" spurs of one year are the "flowering" spurs of the following year and *vice versa*. Spurs which flower and fruit in any one year will almost certainly be "vegetative" during the succeeding year. The annual cropping of these trees, in so far as it can be achieved, is due to a more or less even distribution of spurs which are "vegetative" and those that are "flowering" in any one year. Regular cropping therefore would appear to depend upon maintaining this desirable condition. The onset of biennial bearing would occur when all the spurs flower and fruit in any one year.

Turning next to the variety Worcester Pearmain, it is found that the growth and spur habit is very different from that of Lane's Prince Albert. This variety produces the majority of its flowers in any one year at the ends of short one year old shoots. Detailed observation shows that one or two of the bourse buds of a flower truss develop into shoots, and that these are almost invariably terminated by a blossom bud. It is difficult, therefore, to decide between "spurs" and "laterals." In this case all shoots of less than six inches long were called spurs. It is unfortunate that an accident caused the removal of a considerable number of growths labelled as "spurs." Only those present throughout the observational period will be discussed, although the numbers are rather small.

In spring 1928, 35 spurs were labelled as flowering and of these, four "set" fruits which developed to maturity. All of these spurs blossomed again in spring 1929, thus showing 100% successive blossoming. Of these successively blossoming spurs 49% "set" fruits in the second year. Three of the four spurs which fruited in 1928 also fruited in 1929. It is unfortunate that so many of the

"vegetative" spurs of 1928 were lost, but of those ten which remained 90% blossomed in spring 1929, and half of them carried fruit to maturity.

It is evident that the variety Worcester Pearmain behaved differently from Lane's Prince Albert, in that it exhibited a remarkably strong tendency to successive blossoming and showed a remarkable capacity for successive fruiting. This condition is in marked contrast to that found in Lane's Prince Albert. The annual cropping of Worcester is undoubtedly associated with its growth habit and the fact that it bears a large part of its crop on one year old shoots. From the physiological standpoint this is important, since the spur is a somewhat special order of plant organ.

From this rather elementary examination of the positions at which the majority of the blossoms occur on the two varieties under discussion, it must be evident that apple varieties vary greatly in this respect. Most varieties fall at once into the "spur bearing class," but others, *e.g.* Worcester and Lord Hindlip, and to a less extent, Allington Pippin, fall into a class that may be termed "tip bearers."

It has been shown by some recent work at Long Ashton that the fruits from the "terminal" and "lateral" positions in the cluster exhibit differences in shape and flavour. Attention is called to the fact that apples produced at the two positions upon the same tree, *viz.* (a) terminally on one year old wood and (b) upon well produced spurs, may also be growing under very different physiological conditions.

In discussing the cause and prevention of biennial bearing the above facts must be given due consideration. It is known, for example, that nearly all varieties bear their first few crops at the tips of one year old shoots. It is also well known that biennial bearing does not begin in any variety until the trees are reasonably mature and have ceased to make vigorous annual extension growths. Growth and the onset of biennial bearing are obviously closely associated. It is in fact difficult to see how a Worcester could become biennial so long as it makes some new growth each year. Biennial bearing is confined to spur bearing varieties, and notably to those that are relatively precocious.

These are the working ideas which underline the investigation outlined in the next section of this paper.

II. THE EFFECT OF BLOSSOM AND FRUIT THINNING ON BIENNIAL BEARING OF EARLY VICTORIA.

It was suggested in Part I of this paper that once biennial bearing becomes established, it is extremely difficult to correct. It has also been indicated that it is the "spur" bearing varieties that are most liable to become biennial, and furthermore that the habit is more pronounced in fully mature trees. These suggestions follow naturally from the observations that individual spurs have a very strong tendency to blossom in alternate years.

The onset of biennial bearing would appear to coincide with the time when practically all the spurs on any tree blossom and fruit in any one year. So long as the trees are growing vigorously and there is a regular succession of young spurs produced each season the onset of biennial bearing may be delayed indefinitely.

Any attempt to prevent or correct biennial bearing must recognise these facts. Annual bearing in fully mature trees in the "spur" bearing varieties is associated with a condition in which only half of the spurs are fruiting at any one time. It should, therefore, be possible to induce this condition in a tree by suitable pruning and cultural treatment. Such treatments must be directed towards producing new spurs, reviving the older spur systems and putting some spurs out of "step" with the others as far as blossoming is concerned.

The present section deals with some blossom and fruit thinning experiments which were designed to test the validity of these ideas.

Experimental Material and Method.

Nineteen trees of the apple variety Early Victoria upon the rootstock M.II were available for this work. They stand upon a uniform site and constitute two complete rows running across a large block of trees. They are fourteen years old and not fully grown, but because they were laid down to a grass sod treatment in 1928 they were only of medium vigour. They have been pruned regularly each year by tipping all leading shoots, removing all crossing and unnecessary branches and giving a slight spur pruning where it was considered necessary. The trees are in good condition and are typical specimens of the variety.

The experiment was started in spring 1929, when all blossoms were removed from all the trees in order to place them upon a

uniform basis. This removal of blossoms was carried out at the "pink bud" stage by pinching out the clusters of blossoms and leaving the basal clusters of leaves intact. As the result of this treatment it was hoped that all trees would flower profusely in spring 1929.

The experimental blossom and fruit thinning treatments carried out are as follows :—

Treatment I. Fifty per cent. blossom thinning (5 Trees).

In this treatment alternate blossom trusses were removed each year. The spur leaves were not removed. The treatment was carried out on each occasion by starting at the base of each branch and removing alternate blossom trusses. All fruits set were allowed to develop until July, when the trusses were picked over and all fruits of marketable size were harvested. This constitutes a fruit picking for "early market." The remaining fruits were allowed to develop until they were fully mature and were harvested in August.

Treatment II. Fruit thinned to one per truss (5 Trees).

In this treatment all blossoms were allowed to set fruits normally. Immediately following the "June drop" the trees were carefully examined and fruits were thinned down to one per truss. In all cases where possible the largest fruits were left on the tree. A fruit picking for "early market" was carried out as in the case of Treatment I. The remaining fruits were harvested at full maturity in August.

Treatment III. Thinning for "early market" only (5 Trees).

In this treatment all fruits set were allowed to develop until July when the trees were picked over for early market as in the case of Treatments I and II. The remainder were harvested at maturity in August.

Treatment IV. Control Trees (4 Trees).

All fruits were allowed to develop until they were harvested at maturity in August.

The above treatments have been repeated each spring upon the same trees, thus giving a cumulative effect. Records relating to the following points have been kept : the number of blossom trusses produced each spring ; the number removed in Treatment I ; the number of fruits removed in Treatment II ; the number and weight of fruits removed for early market in Treatments I, II and III ; and the total crop harvested.

Results.

The experiment has now been continued for five years. The available data have been tabulated and are presented in summary form in Table I. In the first place it should be pointed out that the deblossoming treatment which was carried out upon all trees in spring 1928 resulted in a remarkably uniform blossoming in spring 1929. Thus it is shown in Table I that the average numbers of flower trusses produced per tree were 741 ; 743 ; 762 and 820, for Treatments I to IV respectively.

In the first year of the treatments—spring 1929—an average of 370 flower trusses was removed from each tree under Treatment I, and 808 fruits from each tree under Treatment II. When the trees were picked over for the early market fruits, averages of 98, 114, and 114 fruits per tree were obtained under Treatments I, II and III respectively. The total yields for the year were 92, 88, 115 and 117 lbs. per tree for Treatments I to IV. In the first year, therefore, the blossom and early fruit thinning treatments (*i.e.* I and II) reduced the total crop by about 20 lbs. per tree as compared with the trees thinned for early market only, or all fruits left until full maturity (*i.e.* Treatments III and IV).

In spring 1930, the effects of the previous season's treatments were evident in the number of flower trusses produced per tree. The trees showed averages of 690, 498, 337 and 228 flower trusses for Treatment I to IV. It is significant that the trees under Treatment I should have produced three times as many flower trusses as the trees under Treatment IV. The trees of Treatment II had twice as many blossom trusses as those of Treatment IV, and even Treatment III showed an increase of one hundred blossom trusses over those of Treatment IV. Clearly, therefore, the thinning treatments of 1929 had affected blossom bud formation.

In spring 1930, Treatments I and II resulted in the removal of 345 flower trusses and 416 fruits per tree respectively. Treatment II was particularly drastic in this year, since it left only 181 fruits on each tree. In this season as compared with 1929, only half the number of fruits were available for early market, being 50, 51 and 42 respectively for Treatments I, II and III. The average crops per tree were also very low ; 51, 51, 50 and 49 lbs. respectively.

In spring 1931, the effects of the several treatments were not so evident in the number of flower trusses produced as they were in the spring of 1930. The trees under all four treatments blossomed profusely, those of Treatment I the most heavily. The carrying out of Treatments I and II in spring 1931 resulted in the removal of 788 blossom trusses and 581 fruits for the respective treatments.

In this year Treatment II, *i.e.* thinning the fruits to one per truss, gave by far the most fruits that were large enough for the early market crop in July. The numbers were 102, 149 and 115 for Treatments I, II and III respectively. The highest total crop per tree was given by the control trees with 117 lbs. per tree, followed by Treatments II, III and I, with 106, 95 and 88 lbs. per tree respectively.

In spring 1932, it was again evident that the trees under Treatment I—blossom thinning—had produced the highest number of flower trusses per tree. The numbers were 1227, 1128, 906 and 787 respectively for Treatments I to IV. It is particularly interesting to note that the trees of Treatment I should have almost twice as many blossoms per tree as those of Treatment IV (control).

In this year, as in the previous one, the trees of Treatment II yielded by far the most fruit for “early market”—151 fruits as against 102 and 114 for Treatments I and III. The trees of Treatments II and III gave the highest total yields per tree, 139 and 138 lbs. per tree, as against 126 and 119 for Treatments I and IV.

In 1933 Treatments IV and II had more blossoms per tree than those of Treatments I and III. Treatments II and III both yielded more fruits for early market than Treatment I. The weight of fruit removed from each tree for early market was 47, 54 and 56 lbs. for Treatments I, II and III. In total yield Treatment II showed the highest figure at 177 lbs. per tree, followed by Treatment III with 165 lbs.; Treatment IV with 164 lbs., and Treatment I with 14 lbs. per tree.

Discussion.

The data that have been thus far accumulated do not allow of any but very limited conclusions regarding the effects of the several treatments upon biennial bearing. Inherent weaknesses in the experimental method, and the fact that the trees under experiment have continued to grow and produce new spurs each year, are no doubt largely responsible for the lack of results. It is realised that Treatments I to IV have not given sufficiently differing results to allow of anything but a very general discussion. Furthermore Treatment I is particularly drastic, since each year it automatically reduces the possible crop by half. This treatment requires modification in order to allow the effects of one year to be shown in the following one, not only in blossom production but also in fruiting. As the treatment is carried out at present, the profuse blossoming which results from the previous year's treatment is heavily penalized as regards fruiting by the removal of half the flower trusses. Thus,

in spring 1931, the trees of Treatment I were only allowed to set fruits on 635 blossom trusses, although they produced 1,577 of them. Trees under Treatment IV (control) in this year were allowed to set fruits upon 1,028 flower trusses. The possibility of making a high total yield is therefore heavily weighted in favour of these latter trees, under the present system of blossom thinning.

In spite of these criticisms several very interesting facts emerge. In the first place, the trees under the blossom thinning treatment (Treatment I) have produced a very regular number of flower trusses each spring. The numbers were 741, 690, 1,577, 1,227 and 1,513 for the years 1929 to 1933 inclusive. The trees of Treatment IV (control) on the other hand have shown a marked biennial tendency in the number of flower trusses produced, the numbers being 820, 228, 1,397, 787 and 1,608 for the same period. It is particularly interesting to note that notwithstanding the marked biennial tendency in the number of flower trusses produced, these trees, with the exception of 1930, have produced a fairly uniform crop of fruit each year. There is certainly no suggestion of biennial cropping in these trees although there is a marked biennial tendency in their blossom production.

Treatment II which consists of thinning the fruits to one per truss after the June drop has on the whole given the best results. The trees under this treatment have blossomed steadily each spring and have given the highest average number and weight of fruits for early market. It is perhaps not surprising that this treatment should have resulted in the largest number of fruits for early market because, at the thinning time in May, the largest fruits were allowed to remain on the trees and there was no competition between fruits on the same spur, as was often obtained in the other treatments.

Treatment III which consists of leaving all fruits that set until the fruit picking for early market has been associated with a very definite biennial tendency in flower production, but not in cropping. It is interesting to notice that although these trees show the lowest mean number of flower trusses produced over the five year period, yet they have given a yield equally as high as that of Treatments II and IV and higher than that of Treatment I.

The effect of the several treatments upon the total weight of crop harvested is almost negligible since the difference between the average yield over the five years is only 13 lbs. per tree, the yields being 100, 112, 112, 113 lbs. for Treatments I—IV.

It must be admitted that up to the present these several treatments have not materially influenced the onset of biennial bearing, since all the trees irrespective of treatment are still bearing excellent

crops of fruit annually. There are slight indications that Treatments III and IV are associated with a biennial blossoming, but so far this has not been accompanied by biennial cropping. It is impossible to give a definite reason for this at the moment. It is suggested, however, that it is due to youth and vigour of the trees under investigation. They are still producing a fairly large number of new spurs each year and these may very well be the cause of the annual cropping. The treatments are being continued with the object of seeing whether, over prolonged periods, they will ultimately affect biennial cropping tendencies.

A new series of experiments has also been started, including further treatments designed to prevent the onset of biennial bearing. In this case the drastic procedure of Treatment I of the present series has been so modified that only the young spurs are blossom thinned. This latter experiment will also be continued over a long term of years.

RASPBERRY VARIETIES.

AN IDENTIFICATION KEY AND NOTES ON VARIETAL CHARACTERS.

By C. R. THOMPSON.

The old writers assert that *Rubus Idaeus* grew on Mount Ida, of classical celebrity; hence its specific name (1). Many varieties have already been recognised by systematic botanists, but only two of them have played a prominent part in the development of the commercial sorts of the present day, viz.: *Rubus Idaeus Vulgatus* and *Rubus Idaeus Strigosus*. During recent years, however, an important American variety, *Rubus Idaeus canadensis* (2) which is found growing wild in Manitoba has also attracted the attention of plant breeders, and is now being used as a parent in hybridisation work.

As early as 1916 the need for work upon the nomenclature and purity of raspberry stocks was recognised and definite steps to this end were initiated by workers at both East Malling and Long Ashton (3 & 4). Since that time the introduction of several new varieties has further complicated the problem of identification.

In the Annual Report of this Research Station for 1930 a preliminary report of the raspberry variety trials was published (5). Since that time records have been taken for a further period of two years which have in every way confirmed the opinion on varieties as expressed in that report. The comprehensive description concerning the respective merits and failings of 19 commercial varieties combined with the collected crop weight figures for a period of four years serve as a useful guide to intending planters. The present article is based on notes collected on the varieties included in this variety trial previously reported.

The difficulty of obtaining raspberry varieties true to name is appreciated by all who are concerned in their culture, and the main purpose of this paper is thus to present a Key for variety identification. This key and the supplementary notes should help growers and nurserymen to name varieties and at the same time to detect the presence of rogues.

THE CONSTRUCTION AND USE OF THE KEY.

Two of the chief features by which varieties can be grouped are made use of in Tables I and II.

In Table No. I the varieties are grouped into three colour groups, viz. Red, White and Light Brown, according to the colour of the mature canes. Although it is almost impossible to name any variety with certainty on the basis of a distinctive cane colour, yet this character undoubtedly serves as an outstanding feature for variety groupings for identification purposes.

In Table No. II the varieties are further grouped according to the colour of the spines which occur on the young developing canes. The contrast between the varieties with dark and pale coloured spines respectively is most marked, and when this feature is used in conjunction with mature cane colour the resultant groups become sufficiently small to treat separately. When the term "pale" is used in connection with spine colour the spines are on the whole inconspicuous since they are very similar in colour to the new growing canes themselves, *e.g.* Red Cross; whereas in the groups with dark coloured spines the contrast between the purple to almost black spines and the green cane is very pronounced, *e.g.* Lloyd George. As might be expected, there are certain minor differences in colour shade and intensity within the groups themselves, varying slightly with season and locality, but these differences are not sufficient to prevent easy and definite classification. Only canes that have made one foot or more of growth can be regarded as reliable when comparing spine colour, since smaller canes are generally covered with long coarse hairs which are apt to obscure the true nature and colour of the spines.

During winter the only feature by which varieties can be grouped is their mature cane colour, but for a considerable period during the summer season this character can be used conjointly with the spine colour on the growing canes.

TABLE I.
SHOWING RASPBERRY VARIETIES CLASSIFIED ACCORDING TO MATURE CANE COLOUR.

MATURE CANE COLOUR.		
RED.	LIGHT BROWN.	WHITE.
Bath's Perfection.	Baumforth B.	Bourton Coombe.
Baumforth A.	Hornet D.	Brockett Hall.
" C.	Improved Beehive.	Lloyd George.
" E.	Norfolk Giant.	Maclaren's Prolific.
Black Antwerp A.	Parson's Fillbasket.	Northumberland Fillbasket
Devon.		Norwich Wonder.
Duke of Cornwall.		Red Cross.
Goliath.		Semper Fidelis A.
Helston.		
Herbert.		
Hornet A.		
Preussen.		
Pyne's Royal.		
Reader's Perfection.		
Semper Fidelis D.		
Viking.		

TABLE II.
SHOWING VARIETIES CLASSIFIED ACCORDING TO SPINE COLOUR ON GROWING CANES.

MATURE CANE COLOUR.			
MATURE CANES RED.		MATURE CANES LIGHT BROWN.	
<i>Spines on Growing Canes Dark.</i>	<i>Spines on Growing Canes Pale.</i>	<i>Spines on Growing Canes Dark.</i>	<i>Spines on Growing Canes Pale.</i>
Hornet A. Pyne's Royal. Reader's Perfection. Semper Fidelis D. syn. Bountiful.	Bath's Perfection. Baumforth A. " C. " E. Black Antwerp A. Devon. Duke of Cornwall. Goliath. Helston. Herbert. Preussen.	Baumforth B. Norfolk Giant.	Hornet D. Improved Beehive. Parson's Fillbasket.
		Bourton Coombe. Brockett Hall. Lloyd George. Norwich Wonder. Semper Fidelis A.	Maclaren's Prolific. Northumberland Fillbasket* Red Cross.

* Included in this group although spineless.

TABLE II (A).
SHOWING VARIETIES CLASSIFIED ACCORDING TO CANE HABIT.

MATURE CANES RED. SPINES ON GROWING CANES PALE.			
CANES DWARF.		CANES MEDIUM TO VIGOROUS.	
<i>Canes Erect.</i>	<i>Canes Spreading to Straggling.</i>	<i>Canes Erect.</i>	<i>Canes Spreading to Straggling.</i>
Baumforth E.	Baumforth C. Black Antwerp A.	Bath's Perfection. Duke of Cornwall. Preussen. Viking.	Baumforth A. Devon. Goliath. Helston. Herbert.

A further feature which gives character to a raspberry variety is the particular habit of its cane, whether vigorous or dwarf, whether erect or straggling. Goliath and Viking are examples of very vigorous varieties, and Pyne's Royal and Black Antwerp A. examples of very dwarfing varieties, but the canes of Pyne's Royal on the one hand are very erect, whereas those of Black Antwerp A. are very straggling. The term "spreading" which is occasionally used implies an intermediate stage between the erect and straggling habits.

Since the Red Cane, Pale Spine sub-group of Table II contains a large number of varieties, Table IIA has been constructed showing a further sub-division of the varieties on the basis of relative cane habit. For the varieties not included in this group a description of relative cane habit is included in the notes that follow for each variety.

DISTINGUISHING CHARACTERS OF VARIETIES.

Group : Mature Canes Red.

Sub-Group : Spines on Growing Canes Dark.

Varieties : Hornet A.

Pyne's Royal.

Reader's Perfection.

Semper Fidelis D. syn. Bountiful.

Of the varieties in this sub-group, Bountiful and Semper Fidelis D. appear to be similar in every respect and are therefore considered to be one variety.

Hornet A.

Canes. Dwarf and erect in habit. *Leaves.* Dark shiny green colour, slightly curled. *Fruit.* Early, large, conical, firm, deep red, dull, very sweet.

Pyne's Royal.

Canes. Dwarf and erect in habit. *Leaves.* Very dark green, curled and crinkled in appearance (this being one of the main features distinguishing Pyne's Royal from Hornet A.) *Fruit* Mid-season, large, conical, firm, variable red, dull, rather coarse in appearance, excellent flavour.

Reader's Perfection.

Canes. Medium-vigorous, spreading. *Leaves.* Medium green, almost flat, fairly large. *Fruit.* Mid-season, of short duration; medium size, conical, breaks easily, dull dark red, poor flavour.

Semper Fidelis D. syn. Bountiful.

Canes. Medium in vigour, spreading. *Leaves.* Medium-dark green, fairly flat. *Fruit.* Mid-season, medium size, conical, mashy (on account of difficulty in separating the berry from its plug), deep red, sharp flavour.

General Notes.

The two varieties of this sub-group which are classed as dwarf, viz. Hornet A. and Pyne's Royal are rather subject to Mosaic disease, whereas Reader's Perfection and Semper Fidelis D. show a fairly marked resistancy. Reader's Perfection, however, is very subject to Anthracnose; with this variety both fruit quality and yield have proved to be much better when grown under shaded conditions. Although Semper Fidelis D. is resistant to Mosaic it is a variety of very little commercial use chiefly on account of the difficulty in picking. Hornet A., although not one of the highest yielding varieties, is a very useful sort for private gardens and high class trade. Pyne's Royal is probably the best flavoured and largest berry of any variety in cultivation; it needs careful picking to obtain the best sample since the fruits are inclined to ripen somewhat unevenly. It also responds to liberal manurial treatment and prefers sandy soils.

Group: Mature Canes Red.**Sub-Group: Spines on Growing Canes Pale.****(1) Varieties with Dwarf Canes, Erect in Habit.**

Variety: Baumforth E.

Leaves. Shiny dark green, held flat. *Fruit.* Mid-season—late, medium size, large drupelets, round, firm, bright shiny red in colour, rather sharp flavour.

General Notes.

Baumforth E. is a rather low yielding variety which is rather subject to mildew but fairly free from Mosaic.

(2) Varieties with Dwarf Canes, Spreading to Straggling in Habit.

Varieties : Baumforth C.
Black Antwerp A.

Baumforth C.

Canes. Dwarf-medium in height, spreading. *Leaves*. Darkish green, somewhat curled. *Fruits*. Mid-season, small, round, soft, pale colour, very poor flavour, considered by many as unpleasant.

Black Antwerp A.

Canes. Very straggling and spiny. These are the outstanding characters by which this variety can be identified. *Leaves*. Medium-dark green, fairly long and narrow, slight folding lengthwise. *Fruit*. Mid-season, small, almost round with slight elongation, firm, deep shiny red, rather acid.

General Notes.

The very straggling habit and small size of the fruit of Black Antwerp A. detract from the commercial usefulness of this variety ; it is, however, resistant to Mosaic. Baumforth C. has no redeeming features to give it commercial importance. In addition to the many drawbacks which can be gauged from the description above, it gives very poor crop yields and is rather subject to Mosaic.

(3) Varieties with Canes Medium to Vigorous, Erect in Habit.

Varieties : Bath's Perfection.
Duke of Cornwall.
Preussen.
Viking.

Bath's Perfection.

Canes. Medium vigour. *Leaves*. Medium green, shiny surface, rather flat, characteristic bronzing at shoot, which is also common to the majority of varieties derived from Bath's Perfection. *Fruit*. Mid-season, small-medium, round, very firm, bright red, fair flavour.

Duke of Cornwall.

Canes. Medium vigour, erect to spreading. *Leaves.* Medium green, dull surface, somewhat curled in appearance. *Fruit.* Mid-season, large, round, firm, dull whitish red, sweet.

Preussen.

Canes. Vigorous, often over 6ft. tall, bent over at tip. *Leaves.* medium green, somewhat curled, large. *Fruit.* Late, large, conical, firm, rather large and coarse drupelets, pale in colour, moderate flavour.

Viking.

Canes and Foliage. Very similar to Bath's Perfection, although canes are much taller, often over 6ft. tall. *Fruit.* Mid-season to late, medium size, conical to almost wedge shape, soft, bright red, very sweet. The berry has a noticeably large plug.

General Notes.

Bath's Perfection and Viking have shown a marked resistancy to Mosaic. Viking has only recently been introduced from Canada ; it possesses useful dessert qualities and gives considerably higher crop yields than Bath's Perfection. Duke of Cornwall is a comparatively new and heavy yielding variety, well suited to West Country conditions, but rather subject to Mosaic. Preussen has been recently introduced from Germany and is a variety of real promise. It is known to be subject to Mosaic, although at the present time it is impossible to say to what extent. It is a late variety of high crop yield, the berry being rather similar in appearance to Pyne's Royal.

(4) Varieties with Canes Medium to Vigorous, Spreading to Straggling in Habit.

Varieties : Baumforth A.
Devon.
Goliath.
Helston.
Herbert.

Baumforth A.

Canes. Very spiny. *Leaves.* Pale mottled green, almost flat. *Fruit.* Mid-season—late, medium size, round, soft, drupelets large and inclined to break, bright red on canes but generally bruised in appearance after picking, rather acid in flavour.

Devon.

Canes. Medium vigour, spreading. *Leaves.* Light green, somewhat curled, often much yellowing due to a peculiar form of chlorosis which feature serves to distinguish the variety under most conditions. *Fruit.* Late, small-medium in size, round, dry, easily breaks, whitish red, sweet.

Goliath.

Canes. Very vigorous, often over 6ft. tall, spreading, rather spiny. *Leaves.* Medium green, flat, very large, of coarse appearance. *Fruit.* Mid-season, small, large drupelets which break apart, almost purple red in colour, sweet.

Helston.

Canes. Medium-vigorous. *Leaves.* Medium—dark green, have a characteristic curl or fold at the apex of each leaflet, which serves to distinguish the variety. *Fruit.* Late in season, medium size, conical, very narrow and tapering, rather delicate pink-red colour, acid in flavour.

Herbert.

Canes. Vigorous, rather spiny. *Leaves.* Have a characteristic dark shiny green appearance, somewhat curled, young shoots bronzed. *Fruit.* Mid-season, large, round, rather soft, bright red, somewhat acid.

General Notes.

The varieties Baumforth A., Goliath, and Herbert are classed as very spiny, and for this reason are not liked by fruit pickers; particularly is this the case with Baumforth A. Although this last variety gives very heavy crop yields and is resistant to Mosaic, it is of little use for dessert purposes; but is useful for jam making. Goliath on the other hand, is very subject to Mosaic and has no commercial use. Herbert is a variety of Canadian origin and has only of recent years been introduced into this country; it is very resistant to Mosaic, and well deserves trial since it has consistently produced a high crop yield of good quality berries. Helston is a fairly good late variety of medium crop weight and apparently free from Mosaic. With regard to the variety Devon, there are only a limited number of sites where it can be grown with success, since it usually develops Chlorosis and produces an exceptionally dry berry.

Group : Mature Canes Light Brown.

Sub-Group : Spines on Growing Canes Dark.

Varieties : Baumforth B.
Norfolk Giant.

Baumforth B.

Canes, Medium-vigorous, spreading. *Leaves*. Pale-medium green, slightly convex leaflets. *Fruit*. Mid-season, medium size, conical, dry, firm, dull red with whitish sheen, giving it a pale colour, very sweet.

Norfolk Giant.

Canes. Very vigorous, often over 6ft. tall, fairly erect. *Leaves*. Medium green, slightly convex leaflets, very large. *Fruit*. Late, medium to large, conical, medium-soft texture, deep red, fairly sharp.

General Notes.

Norfolk Giant is one of the comparatively new varieties which shows distinct commercial merit. Although not free from Mosaic, it is one of the highest yielding varieties, and is a variety recommended by the canning industry. Baumforth B. is a very good dessert variety and is resistant to Mosaic ; unfortunately it seldom gives large crop returns.

Group : Mature Canes Light Brown.

Sub-Group : Spines on Growing Canes Pale.

Varieties : Hornet D.
Improved Beehive.
Parsen's Fillbasket.

Hornet D.

Canes. Vigorous, often over 6ft. tall, spreading. *Leaves*. Medium green, fairly flat, large. *Fruit*. Mid-season, small, consist of a few large drupelets which break apart on picking, dull medium red in colour, sweet.

Improved Beehive.

Canes. Dwarf, straggling, very spiny. *Leaves*. Medium green. Leaflets have a characteristic fold lengthwise which gives them a narrow appearance. *Fruit*. Early, small, round, firm, bright red colour, medium-acid flavour.

Parson's Fillbasket.

Canes. Vigorous and erect, often over 5ft. tall. *Leaves.* Medium green, fairly flat. *Fruit.* Late in season, small, round, soft, pale coloured, poor flavour.

General Notes.

Of these three varieties only Improved Beehive can be regarded as commercially useful. This variety is exceptionally prolific, and although of only recent introduction has so far remained free from Mosaic diseases. Parson's Fillbasket and Hornet D. produce very low yields and poor quality berries. Parson's Fillbasket, however, is resistant to Mosaic, whereas Hornet D. is fairly susceptible.

Group : Mature Canes White.**Sub-Group : Spines on Growing Canes Dark.**

Varieties : Bourton Coombe.

Brockett Hall.

Lloyd George.

Norwich Wonder.

Semper Fidelis A.

Bourton Coombe.

Canes. Vigorous, but seldom tall, spreading-straggling. *Leaves.* Have a characteristic mottled grey green appearance, slightly curled. *Fruit.* Mid-season—late, medium size, conical, soft, dark dull red, poor flavour.

Brockett Hall.

Canes. Vigorous, often over 6ft. tall, spreading. *Leaves.* Pale green, somewhat curled in appearance. *Fruit.* Early, medium size, round, firm, pale whitish red, medium to sweet flavour.

Lloyd George.

Canes. Vigorous, but seldom tall, spreading. *Leaves.* Somewhat shiny, medium-dark green. *Fruit.* Early, large, conical, fairly firm, variable colour, moderate flavour.

Norwich Wonder.

Canes. Dwarf-medium, erect. *Leaves.* Pale mottled green, somewhat curled. *Fruit.* Early, large, conical, firm, dull dark red, very sweet.

Semper Fidelis A.

Canes. Medium vigour, rather straggling. *Leaves.* Pale green, corrugated, slightly curled, sparse foliage. *Fruit.* Late, medium size, conical, firm, but inclined to break into drupelets, dry, pale whitish red, poor flavour.

General Notes.

The outstanding variety of this sub-group is Lloyd George. It is one of the highest yielding varieties which feature, together with its earliness and marketing qualities has helped it to attain first place in commercial importance. Unfortunately it is becoming increasingly difficult to obtain nursery material that is free from Mosaic; in this respect it is like Norwich Wonder and even to a more marked extent, Semper Fidelis A. Bourton Coombe is a variety very much like Lloyd George in appearance, although its mottled leaves are the chief distinguishing feature. It appears to do reasonably well under shaded conditions, and is free from Mosaic, but is otherwise not recommended.

In appearance the fruit of Semper Fidelis A. is not unlike Baumforth B., although there is no mistaking the flavour. It is very subject to Mosaic, poor in crop yield and one of the latest varieties to come into bearing. Norwich Wonder is a very useful early season berry, although its season is of only short duration. It produces a berry suitable for high class dessert trade, but yield is not high enough for wide commercial use. Little can be said about Brockett Hall other than that it is one of the recently introduced varieties; it is very prolific and rather subject to Mildew.

Group: Mature Canes White.

Sub-Group: Spines on Growing Canes Pale.

Varieties: Maclaren's Prolific.

Northumberland Fillbasket.

Red Cross.

Maclaren's Prolific.

Canes. Medium vigour, rather spreading. *Leaves.* Very dark green, somewhat curled. *Fruit.* Early, large, conical, rather soft, deep red in colour, acid in flavour.

Northumberland Fillbasket.

Canes. Medium vigour, inclined to spread, spineless. *Leaves.* pale green, slightly curled. *Fruit.* Mid-season, medium size, round, firm, whitish red in colour.

Red Cross.

Canes. Medium to vigorous, rather straggling, somewhat spiny,
Leaves. Pale green, flat. *Fruit.* Mid-season, large, conical, firm,
 dark red ; the drupelets have a rather flattened appearance and are
 covered with a whitish sheen, sub-acid in flavour.

General Notes.

The outstanding variety in this sub-group is Red Cross, which is one of the highest in crop yield and produces an excellent quality fruit, suitable for high class trade. Unfortunately it is very subject to Mosaic, and it is becoming increasingly difficult to obtain good nursery material. Maclaren's Prolific is a good cropping variety, and at the same time one that is resistant to Mosaic ; but its chief drawback is the difficulty experienced in picking the berries from the plug, and particularly is this the case as the season advances. The variety Northumberland Fillbasket is liked by some for private garden purposes, chiefly on account of its spineless nature. It is fairly resistant to Mosaic, but rather subject to Mildew, and gives only poor crop yields.

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FURTHER OBSERVATIONS ON THE JOINT CONTROL OF THE APPLE SAWFLY AND APPLE SCAB.—SEASON 1933.

By H. G. H. KEARNS, R. W. MARSH and T. SWARBRICK.

INTRODUCTORY.

Previous work on this problem has been carried out both at Long Ashton and in commercial plantations. At Long Ashton in 1931 and 1932 (1, 2), it was shown that when approximately 10 per cent. of the flowers of Worcester Pearmain apple were infested with sawfly eggs the resultant loss amounted to 50 per cent. of the crop in unsprayed trees. On the comparable sprayed trees where the flower infestation had been equally high, a satisfactory control was obtained by a nicotine wash applied within a period of twelve days after petal fall. Furthermore, it was noted that a wash containing lead arsenate of fine particle size provided another means of appreciably reducing sawfly damage. It was also found that the addition of lime sulphur to a nicotine wash, with the object of scab control, was apparently not prejudicial to the control of sawfly (3).

In experiments carried out in a commercial plantation (4, 5), the number of washes applied was determined by the intensity of the infestation, and the time of application was chosen after observation of the development of the eggs. This method of timing gave better results than those obtained by an arbitrary selection of spraying date at a definite number of days after petal fall. However, as the designation of spraying date in terms of days after petal fall is exclusively used by growers, and has been employed in the previous articles of this series relating to trials at Long Ashton, it has been retained in the present paper.

The Long Ashton experiments of the 1933 season consisted of spraying trials carried out with the object of obtaining information on the following points :—

- (a) Whether the application of a nicotine wash seven days after petal fall is consistently reliable in controlling sawfly.

- (b) Whether the addition of lime sulphur to a nicotine-Agral I wash results in any reduction in the insecticidal and fungicidal properties of the wash.
- (c) Whether the addition of lead arsenate to a mixed wash of lime sulphur, nicotine and Agral I increases the control of sawfly.

EXPERIMENTAL.

Lay-Out of Trial.

The experiments were carried out in the Long Ashton plantations on the same trees of the Worcester Pearmain variety as were used in 1931 and 1932. These trees form one of the rootstock plots and comprise a block of 96 twelve-year-old trees in twelve rows, all the trees in each row being on the same type of layered rootstock. For the spraying trials the block was divided into groups as in the previous seasons. Eight groups were taken across the block so as to provide one tree per group on each of the twelve rootstocks, the groups thus being comparable in this respect. One group was left as an unsprayed control as in 1932, one group (No. 5) was used for a spraying experiment not dealt with in this paper, and the remaining six were sprayed as described in a later section.

Observations on Infestation.

The following field observations were made on the experimental plot during the flowering season :—

- May 10th. 50 per cent. of the blossom fallen from the lower portions of the trees.
- May 14th. 80 per cent. of the blossom fallen from the lower portions of the trees. On lower branches, less than 3 per cent. of flowers infested with eggs.
- May 17th. Full petal fall from upper branches of trees. 16 per cent. of flowers infested with eggs; uniform infestation throughout the plot.
- May 24th. Seventh day after petal fall. 40 per cent. of the eggs had hatched, and some larval galleries evident on fruitlets.

Washes.

The following washes were used in the experiments :—

Nicotine Wash. The composition was similar to that used in two previous seasons, viz. :—

- 8 fluid oz. Nicotine (98 per cent. purity).
- 2½ lb. Agral I.
- 100 gallons Water.

Nicotine-Lime Sulphur Wash.

1½ gallons Lime Sulphur.
 8 fluid oz. Nicotine.
 2½ lb. Agral I.
 100 gallons Water.

Nicotine-Lime Sulphur-Lead Arsenate Wash.

1½ gallons Lime Sulphur.
 8 fluid oz. Nicotine.
 2½ lb. Agral I.
 2 lb. Lead Arsenate powder.
 100 gallons Water.

Lime Sulphur Wash. The normal post-blossom fungicide wash, consisting of:—

1½ gallons Lime Sulphur.
 100 gallons Water.

In the above formulae, certain points concerning the mixed washes call for attention. The addition of lime sulphur to a nicotine wash has the obvious advantage of reducing the expenditure of time and labour, compared with that taken for applying the two washes separately. Such an addition was not possible while soap was in use as the wetting agent but the newer wetters, which do not form insoluble calcium compounds with lime sulphur, render this mixed wash practicable. The incorporation of lead arsenate in a wash already containing both lime sulphur and a wetter introduces further difficulties. Owing to the amount of reaction between very finely-divided lead arsenate and lime sulphur, resulting in rapid aggregation and precipitation of lead sulphide-coated particles of lead arsenate, it is preferable to use a lead arsenate powder of not more than 300 mesh fineness to mix with a lime sulphur wash. Furthermore, excellent wetting power and heavy applications of wash are essential in sawfly control since it is especially desirable to obtain a deposit of arsenate inside the calyx cup. It is, however, also necessary to obtain a uniform and sufficient deposit of lime sulphur on the foliage against scab, and it is possible that the addition of the wetter may cause a reduction in this deposit. On account of the lack of a reliable method of determining the amount and the nature of the distribution of the sulphur on leaves, it was planned to cover this point by observations on the actual infection of the foliage by apple scab.

Spray Applications.

The sprayings were carried out on May 24th and 25th, seven and eight days after petal fall. The washes were applied at a time

calculated to control the pest on the upper portions of the trees, since these parts showed the highest infestation. The washes were applied to the groups of trees as follows :—

<i>Group No.</i>	<i>Wash.</i>	<i>Days after Petal Fall.</i>
1-3	Lime Sulphur Nicotine Agral I.	7
4	Lime Sulphur Nicotine Agral I. Lead Arsenate	7
6-7	(i) Nicotine Agral I.	7
	(ii) Lime Sulphur	8
8	Lime Sulphur Control for Scab.	8

It is seen from the above that the lime sulphur was applied to groups 6-7 one day after the application of the nicotine wash in order to avoid any possible interference of the lime sulphur with the toxicity of the nicotine.

The washes were applied by means of spray guns, working at a pressure of 350 lbs. per square inch. The trees were dry and the atmospheric temperature high when spraying was carried out, particular attention being paid to thoroughly wetting the fruitlets on the upper branches of the trees. Approximately $1\frac{1}{2}$ gallons of wash were applied to each tree.

RESULTS.

The results of the experiment are given in Table I, which is presented in the same form as that used in 1931 and 1932, except that the total number of fruits set was not recorded, but instead the total number of fruits harvested. For this reason, the final percentage of infested fruits tended to be higher than would have been the case if the previous method of stating results had been retained. At the end of June, when the majority of the larvae were full grown and many had left the fruits, the trees were picked over and all the infested apples, including those that had fallen to the ground, were collected and counted. The variation in infestation of individual trees may be observed in the table.

It is evident from the table that the addition of the lime sulphur to the nicotine-Agral I wash did not interfere with the toxic action

of the nicotine. Thus the nicotine wash applied alone reduced the infestation from 53.9 per cent. to 21.4 per cent. (groups 6-7), and the mixed lime sulphur nicotine to 20.8 per cent. Unfortunately, from the standpoint of this experiment, the scab attack proved to be negligible on all the groups of trees and therefore no information could be obtained as to the influence of the wetter on the control obtained with lime sulphur.

The mixed wash applied to Group 4 reduced the infestation from 53.9 per cent. to 8.0 per cent. Thus the addition of the lead arsenate to the wash resulted in a reduction in infestation 12.7 per cent. (20.8 - 8.06) greater than that obtained with the lime sulphur-nicotine wash.

The control obtained by means of the nicotine wash cannot be considered satisfactory, and was not equal to the results obtained in previous years on the same plot with the same wash. This was expected as it had been found that the best results were obtained by applying a nicotine wash at an earlier stage, and before so high a percentage of eggs had hatched. Similar results were obtained in another experiment, and it was conclusively proved that the best control is obtained when nicotine is used if it is applied just before the majority of the eggs have hatched (5). The Long Ashton experiment showed that the single application of a nicotine wash applied seven days after petal fall does not invariably provide a high control.

SUMMARY.

1. A further trial was carried out at Long Ashton on the control of Apple Sawfly on the variety Worcester Pearmain.
2. It was proved that a high degree of control is not consistently obtained with a single application of a nicotine wash applied 7 days after petal fall. Thus in 1933 an infestation of 53.9 per cent. was only reduced to approximately 21.0 per cent. which control was poorer than that obtained in previous seasons.
3. The addition of lime sulphur to a nicotine-Agral I wash did not cause any reduction in the toxicity of the nicotine. It was impossible to obtain any data on the influence of the addition of a wetter in a wash in so far as Scab was concerned, as the attack was negligible.
4. The addition of lead arsenate to a nicotine-lime sulphur-Agral I wash decreased the infestation by an additional 12.7 per cent. It was evident that the inclusion of the lead arsenate provided a margin of safety against the danger of incorrect timing of spraying.

Groups Nos. 1—3 = 20.8

of Specified Washes at 7 days after Petal Fall.

PEARMAIN.

(4) 24/5/33			(6) 24/5/33, 25/5/33			(7) 24/5/33, 25/5/33.			(8) Control.		
7			7 Nicotine. 8 Lime Sulphur.			7 Nicotine. 8 Lime Sulphur.			—		
Lime Sulphur, Nicotine, and Arsenate, Agral I.			Nicotine, Agral I ; followed by Lime Sulphur.			Nicotine, Agral I ; followed by Lime Sulphur.			Control.		
No. of Fruits In- fest- ed	No. of Fruits In- fest- ed	% of Fruits In- fest- ed	Total No. of Fruits Har- vested	No. of Fruits In- fest- ed	% of Fruits In- fest- ed	Total No. of Fruits Har- vested	No. of Fruits In- fest- ed	% of Fruits In- fest- ed	Total No. of Fruits Har- vested	No. of Fruits In- fest- ed	% of Fruits In- fest- ed
10	2.39		401	38	9.47	210	34	16.19	506	200	39.52
50	7.15		330	32	9.41	578	97	16.7	469	229	48.74
39	7.72		319	59	18.48	346	93	26.87	257	54	21.0
38	11.1		421	85	20.19	346	71	20.5	207	96	46.31
18	6.64		165	22	13.33	243	18	7.41	444	250	56.31
39	14.18		96	10	10.42	249	89	35.74	180	76	42.22
15	7.9		149	27	18.12	126	26	20.6	169	106	62.72
3	4.29		26	0	0	4	1	25.0	208	146	70.19
54	14.47		307	81	26.84	300	87	29.0	247	181	73.2
15	7.8		227	36	15.85	150	57	38.0	286	193	67.74
5	4.48		304	76	25.0	281	103	36.65	372	268	72.31
21	12.28		190	42	22.22	201	103	51.0	223	125	56.0
3585			2935			3034			3568		
307			508			779			1924		
8.06			17.31			25.67			53.92		

Groups Nos. 6—7 = 21.4

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EXPERIMENTS ON THE CONTROL OF THE CHRYSANTHEMUM EELWORM.

(*Aphelenchoides ritzema-bosi* Schwartz.)

SEASONS 1931-1933.

By H. G. H. KEARNS and C. L. WALTON.

Introduction.

The condition of Chrysanthemums known as "black-leaf" or "leaf blotch" is unfortunately only too well known to nurserymen. Its widespread prevalence during the past few years has resulted in the practice of purchasing quantities of cuttings from outside sources in an endeavour to find more profitable varieties. In many cases the "black-leaf" has not been recognised as a condition brought about by a specific organism, but has been attributed to other causes, and thus the practice of purchasing stock from different localities has aided considerably the distribution of the eelworm now known to be responsible for it.

A survey in the Bristol Province of the prevalence of the eelworm showed that it occurred in practically all the nurseries visited, and in many it was responsible for serious losses, making it impossible to grow some of the most profitable varieties. Only a small percentage of growers were able to diagnose the trouble as a disease.

During the 1931-1933 seasons investigations on this problem have been carried out at three centres; by Edwards at Harper Adams Agricultural College, Hodson at Reading University, and at Long Ashton Research Station. Of these, two have been reported, by Edwards (1), and Hodson (2). The results of the Long Ashton experiments are included in this paper where it is shown that the control of eelworm by means of nicotine washes is unsatisfactory, whereas good results are obtained by hot water treatment of infested stools. The results obtained at the three centres agree in the more important aspects and all show that the most satisfactory control is obtained by taking cuttings from hot water treated stools.

The Eelworm and Nature of Infestation.

The morphology and certain aspects of the life history of the eelworm have been described by Stewart (3) and others, and therefore only the essential details in so far as they bear relationship to methods of control are mentioned in this account.

The eelworm is microscopic in size but it can be easily seen, particularly if active, in a liquid medium under the low power objective of a microscope. The adult worm is approximately $1/250$ in. long, the immature worms which invade the leaf tissues being considerably smaller. It is endoparasitic and passes the greater part of its life cycle within the mesophyll of the leaves. Moisture is essential to enable it to move outside plant tissues, but it is important to note that it can resist considerable dessication and remain in dry soil in an inactive stage for as long as 22 months (5).

The majority of affected plants become infested as cuttings before they are removed from the parent stool. During the growth of an infested plant many of the lower leaves die and fall on the soil around the stool. Later, after the full flowering period, the number of basal shoots produced increases and, as these develop green leaves, the eelworms migrate from the dead leaves on the soil, enter the stomata and find their way into the interior of the young leaves. The movements of the eelworms and their progeny are facilitated by the fact that the shoots at soil level are always moist for some part of each day, particularly when they are kept under greenhouse conditions.

The infested leaves soon exhibit signs of attack by the development of yellowish green patches which later turn black and finally the whole leaf is involved and dies. The extent and the speed of the infection vary; thus if cuttings are kept under humid conditions, the majority may be killed within a period of two weeks.

Generally the infestation of the cuttings is not detected until they are removed from the shoot and planted out. Once a cutting is infested there is little or no chance under normal growing conditions of the plant becoming free. As the plant grows the invasion of the lower leaves proceeds. The extent of the infestation depends almost entirely on the extent of time the plant is subjected to moisture. Prolonged wet weather in spring and summer or heavy dews in late summer are favourable to severe attacks. On the other hand, a dry season such as that of 1933 provides a natural check to the pest; in fact, the infestation in many cases under the conditions then prevailing was almost negligible when it would normally have been severe. It is important to note, however, that slight attacks early in that season provided sufficient

dropped leaves to form the nucleus for infestations of the cuttings. This was clearly demonstrated in the Long Ashton greenhouses.

Identification of Eelworm Attack.

Infested rooted cuttings may be readily recognised by the appearance of the foliage as previously described, but the diagnosis of plants in July and later by this character is not so reliable. Frequently there are other causes of the death of the lower leaves; thus the chrysanthemums in a number of nurseries were examined in November, 1933, and although in most cases the foliage had died up to half of the total length of the plants, it was proved by microscopic examination that eelworm was not responsible. This fact is mentioned as nurserymen who are not experienced in the diagnosis of eelworm are inclined to regard dying off of leaves as a certain symptom of the disease. The death of leaves may be regarded as a suggestive symptom, but it is advisable to confirm the diagnosis by microscopic examination which may be carried out in the manner outlined below.

A random sample of leaves showing some signs of discolouration just above the dead ones is taken. A portion from each leaf is scraped with a knife into minute fragments in a drop of water or normal saline on a glass slide. Usually within a few moments, in the case of infested tissues, active eelworms can be readily seen under the low power of a microscope (about 30 magnification).

In the case of plants grown under dry conditions, when the infestation is very slight, the eelworms are often inactive and are not so readily detected, and it is always advisable in the case of an apparently non-infested plant to examine a number of samples before coming to a final decision. The examination of dried dead leaves is conveniently carried out by soaking the leaves in water and then leaving them in a closed petri dish or tube for three days. By the end of this time if the moisture has been correctly adjusted the material will have macerated and be in excellent condition for a microscopic examination, as the eelworms become very active. This method is also convenient for the examination of large samples of green leaves.

The most convenient method found of detecting eelworm infested soil consisted of planting clean cuttings in the soil and keeping the plants in a humid atmosphere. If eelworms were present in the soil an infestation of the leaves of the cuttings occurred within three weeks under these conditions. A suitable method of obtaining non-infested cuttings for this test is to take cuttings of terminal portions of shoots from vigorously growing plants, and

as a precautionary measure to examine the leaves below the cuttings for eelworm. It was noted in one series of experiments that cuttings, obtained from hot water treated stools and planted in fresh soil in dry pots that had previously contained diseased chrysanthemums, became infested with eelworm. It appeared highly probable that the infestation resulted from eelworms adhering to the pots.

Susceptibility of Varieties.

It was evident from observations in the Bristol Province that there are few highly resistant varieties, though there exists a considerable range of susceptibility to attack. Thus, for example it appears that the varieties Lord Brooke and Wilcox are not as a rule attacked, and there is also general agreement that such varieties as Cheshunt White, December Bronze, Jean Paterson and Favourite are very subject to serious infestation.

According to growers' observations there appears considerable diversity of opinion as to the susceptibilities of the newer varieties; thus a so-called resistant sort at one nursery is often regarded as susceptible at another. On investigation it was evident that in most cases the "resistance" of a newly purchased variety gradually broke down. It seems probable in such cases that originally the so called "resistant" stocks must have been purchased free from infestation, and in the course of a few seasons had become infested from the other varieties, soil, etc., in the nursery.

Smith (4) in 1926 published a provisional list of varieties divided into groups according to the severity of attack, but he laid emphasis on the fact that the list might require revision as the result of further observation.

Control Experiments.

During 1931-1933 three types of control experiments were carried out.

- (a) Treatment of infested rooted cuttings.
- (b) Chemical treatment of stools and cuttings.
- (c) Hot-water treatment of stools.

(a) The Treatment of Infested Rooted Cuttings.

The application of a strong nicotine-soap wash has been recommended and used to some extent for some years as a means of control. This method was unsatisfactory as applied by nurserymen and therefore a special experiment was arranged in which nicotine

and a pyrethrum emulsion were tested carefully as means of obtaining control. Cuttings from infested shoots of Jean Paterson and Crimson Conquest were taken and as soon as they became rooted the plants of each variety were divided into two groups. One group in each case was sprayed with a nicotine wash and the other with a pyrethrum emulsion at intervals of 7-10 days throughout the growing period until in bloom.

The composition of the washes were as follows :—

- (i) 1 oz. Nicotine (95-98%).
 10 gallons Water.
 4 oz. Agral I.
- (ii) Pyrethrum emulsion consisting of pyrethrum extract and a one solution emulsifier. The wash was applied at a concentration that represented 1% of good quality flowers.

It was evident in June that the plants sprayed with the nicotine were less infested with eelworm than those sprayed with the pyrethrum emulsion. By the end of August, after some heavy dews and some rain, both varieties were appreciably infested, but more particularly the pyrethrum group, which was approximately as bad as an untreated control.

It was evident from this experiment that the application of a nicotine wash cannot be considered as a satisfactory means of control, although it aids as a temporary check to the infestation. Moreover, it was noted that at one nursery where regular applications of a nicotine wash of a high concentration were made in the wet summer of 1931, that the infestation became so severe that it was only checked by moving all the plants from outside into open-ended greenhouses. The protection thus afforded to the plants kept them dry and thereby prevented the rapid migration of the eelworm from leaf to leaf.

The toxicity of the Nicotine-Agral I wash to the eelworms was further tested. A large number of worms in teased material were placed in a tube with a quantity of the wash for 18 hours. At the end of this period the nematodes appeared quite dead, but after filtering and washing for twenty minutes with water slight movement was observed in some of the larger specimens within 6 hours. The washed eelworms were then placed in contact with some clean cuttings and these developed "leaf-blotch" within three weeks after inoculation. The control cuttings remained free from infection.

A further experiment was carried out to see if the application of a nicotine wash in any way exerted a toxic action on the eelworms

within the leaf tissues. In this case the application of a wash containing up to 20 fluid ozs. nicotine per 100 gallons of water did not kill the eelworms.

The principle underlying the control of eelworm by means of nicotine is that the wash should kill exposed migrating nematodes. In view of the fact that the duration of effective toxicity of nicotine is limited to a few hours, and that the wash under the very best nursery practice cannot be applied economically at more frequent intervals than about 7-10 days during the growing period, it is evident that there are plenty of opportunities for the eelworms to migrate from leaf to leaf. This fact, in conjunction with the result of the toxicity test above, indicates that spraying with nicotine as a vermicide cannot be of any great value.

(b) Chemically Treated Stools and Cuttings.

Two groups of stools of two badly infested varieties, Cheshunt White and Jean Paterson, were selected for treatment with insecticides just before the aerial portion of the cuttings had developed green leaves. One group was treated with nicotine-Agral I, and the other with pyrethrum emulsion. A second application of the washes was watered on as soon as the first green leaves developed. Cuttings were taken within three weeks of the final application of the insecticides, and before they were planted in fresh soil they were again dropped in the washes.

Practically all the plants so treated were observed to be infested with eelworm before they were ready for planting in 10 in. pots.

The soluble saponins present in Mawrah Meal are toxic to earthworms and root-worms (*Enchytraeidae*), and it was thus considered worth while testing their toxicity to the eelworms in the following manner :—

The cuttings from some infested Cheshunt White stools were removed and the stools planted. The soil around each stool was dressed liberally with Mawrah Meal at the rate of $\frac{1}{2}$ lb. per square yard at intervals of 7 days; the shoots subsequently developed, after planting out in clean soil, were found to be infested with eelworm. This experiment was repeated with similar results and it was evident that Mawrah Meal used in this way provided no control of the pest.

The only occasion on which a chemical treatment of the stools provided a satisfactory result was obtained by removing all the cuttings from a number of infested stools, then thoroughly washing off all the soil, and finally soaking the stools in a nicotine solution

(2 oz. per 10 gallons water and 1 oz. Agral I) for one hour. The object of this treatment was to endeavour to incapacitate the eelworms by means of the nicotine and thereby assist in removing them by washing from the stool. After a delay of 5 weeks some cuttings developed which remained non-infested through the season and formed a marked contrast to the untreated controls. This experiment was repeated on a large scale in 1933, but unfortunately the infestation of the control was almost negligible, and it was impossible to obtain any further data. The treatment took a considerable time, and for that reason could not be adopted on a commercial scale.

(c) *Hot Water Treatment of Stools, 1933.*

Numerous experiments on the treatment of unrooted cuttings with hot water at various temperatures for different periods of time showed quite clearly that it was impossible to obtain a control of eelworm without killing a high percentage of the cuttings.

At the suggestion of Mr. W. E. H. Hodson, the treatment of the stools of infested plants with hot water was carried out.

Stools of the varieties December Bronze, Jean Paterson, Balcombe Beauty, Cheshunt White and Maurice were selected for the experiment. In mid-January, after the flower crop was over, the plants were cut down and the well developed basal shoots removed. The stools were thoroughly washed to remove the earth and then placed in water at 110°F. for 20 minutes. After cooling the stools were planted in steam sterilised soil. The removal of the shoots and subsequent treatment with the hot water delayed the development of fresh shoots for three weeks, but none of the stools were killed.

Over 1,500 cuttings, including those from the controls, were taken and throughout the growing season were grown in soil contained in pots, both soil and pots having been previously steam sterilised. Microscopic examinations of the lower leaves on the plants were made at regular intervals during the season. The eelworm infestation was negligible on all the controls except those of the variety Balcombe Beauty. In this case 53 per cent. of the plants were infested, compared with 3 per cent. of the plants obtained from the treated stools.

There was considerable dying off, amounting to approximately one-third to one-half the total length of the plants, of the lower leaves of all the plants during the growing period. These leaves in some cases fell from the plant, but in most cases adhered to the stem. There was no doubt that this dying was caused by some factor other than eelworm attack.

Similar experiments were carried out with similar results at various nurseries in the Province. The plants obtained from the hot water treated stools flowered 2-3 weeks later than the control plants.

In another experiment a number of stools of the varieties Valet and White Rose from which all the shoots were removed were divided into groups. Each group was treated for 20 minutes with water at different temperatures. It was found that hot water treatment at temperatures below 119°F. did not appear to have any ill effects on the capacity of the stools to produce shoots. One batch of stools was placed in water at 115°F. The temperature on immersion dropped immediately to 110°F., and within 10 minutes attained 125°F. where it was maintained for 5 minutes. This temperature was reduced to 110°F. for the remaining 5 minutes of treatment. 59 per cent. of these stools failed to develop shoots, but the remainder recovered and at the end of 7 weeks produced satisfactory cuttings.

Recommendations.

1. The preliminary experiments indicate that a satisfactory control of eelworm may be obtained by immersing infested stools in hot water maintained at 110°F. for twenty minutes.

Temperatures in excess of 115°F. should be avoided as they retard the production of basal shoots.

2. The stools required for propagation should be treated some weeks before the normal time of taking cuttings, as the hot water treatment temporarily delays the growth of the basal shoots.

3. It is essential that the treated stools and resultant cuttings be grown in soil free from eelworm and care must be taken to ensure that any pots or boxes used are also free from the pest.

Acknowledgments.

The authors wish to record the valuable help of Messrs. Clifford and Sons, South View Nursery, Bath. Messrs. Coombe and Sons, Bath, and Mr. W. V. Bateman, Bristol.

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OBSERVATIONS ON THE PEA STRAIN OF THE EELWORM *HETERODERA SCHACHTII* AND ITS RELATION TO "PEA SICKNESS."

By C. L. WALTON, L. OGILVIE, and B. O. MULLIGAN.

In the course of the vegetable disease survey carried out in the Evesham district of Worcestershire by two of us (Ogilvie and Mulligan) it was found, in 1931, that the eelworm *Heterodera schachtii* was very widely prevalent on the roots of peas; this discovery was reported in the "Gardeners' Chronicle" (6) and has also been recorded by Dr. M. J. Triffitt in the "Journal of Helminthology" (9).

Symptoms.

When severely attacked the affected plants are greatly dwarfed, rather pale in colour, and tend to die off at an early stage. Later in the development of the plants, the minute creamy-white and finally chestnut brown cysts of the female eelworm may be found on the roots in large numbers. Affected areas usually occur in circles or patches in the fields, diseased and healthy areas being sharply defined.

Previous References and Distribution.

The potato strain of *Heterodera schachtii*, associated with "potato sickness," has of course been known in England for many years, but, as will be seen later, the strain occurring on peas is apparently quite distinct. Goodey, in his recent "Plant Parasitic Nematodes" (3) gives several previous records. The eelworm was found on peas in Germany by Liebscher (5) in 1890, and appears to have caused serious damage in France, where Capus (1, 2) found it associated with a fungus, *Fusarium vasinfectum* var. *Pisi* Schik. (now *F. Equiseti* (Cda.) Sacc.). Theobald (8) noticed it in England in 1912, and more recently it has been found in Brecon, Cornwall, Cambridge and Glamorgan. In 1931, Triffitt (9) reported attacks from Glamorgan, Worcester, Herts., and Berks. In the "Monthly Summaries of Plant Diseases and Pests" issued by the Ministry of Agriculture in 1933, infested peas were recorded from the following

counties: Surrey, Wilts and Somerset (Fox Wilson), Shropshire and Staffordshire—"very common"—(Edwards), and Sussex (Jary).

As previously indicated we have found the eelworm to be very common and widely distributed on field peas in Worcestershire, and furthermore it is sporadically distributed in gardens throughout Gloucester and Somerset, while infected pea plants collected at Bideford, Devon, have been sent to us by Mr. A. Beaumont. In the Bristol Province thirty infected localities were under observation during 1933.

Goodey (3) states in the course of his remarks on the pea race, "Apart from the early work of Liebscher already referred to and the later records of attack on peas in France and England, no detailed studies . . . on the physiology of this race have apparently been published. Researches are needed . . . on the range of hosts of this race."

It is to meet this want to some extent that the present paper has been compiled.

Relationship with Foot Rots.

It was early observed by us that pea plants on which *Heterodera* cysts were found were also commonly affected with foot rot, caused by various species of *Fusaria*; in fact few, if any, *Heterodera* infested plants have been found to be free from foot rot. It is thus very difficult to ascertain to which organism disease symptoms are due. The foot rot problem is being investigated by two of us (Ogilvie and Mulligan—see Progress Reports on Vegetable Diseases) and, as far as we have gone, it seems that the dwarfing and yellowing symptoms are mainly due to eelworm infestation, premature dying off being mainly due to foot rot infection. It is not considered that there is any intimate relationship between the organisms causing the two sets of symptoms.

EXPERIMENTAL.

Greenhouse Experiments.

1. This trial, carried out in 1931-32, has already been described in the Long Ashton Report for 1931-32 (7). On November 12th, 1931, a large bed was made up in a cold greenhouse at Long Ashton, and about 15 lbs. of soil obtained from an infected field at Evesham were scattered over the surface as evenly as possible, and forked in. Peas of the variety Early Bird were then sown. Germination took

place on November 22nd. The eelworm cysts were first found on the pea roots on April 22nd, and by May 12th were present on almost every root. The following weeds growing on the plot were unaffected by the eelworm: *Brassica Sinapis*, *Capsella Bursa-pastoris*, *Cardamine hirsuta*, *Stellaria media*, *Senecio vulgaris*, *Sonchus arvensis*, *Lamium purpureum*, *Euphorbia Peplus*, *Urtica urens* and *Poa annua*. The pea plants were also affected with a typical "foot rot," from which a fungus considered to be identical with *Fusarium Solani* var. *Martii* (App. et Wr.) Wr. (*F. Martii* var. *Pisi* Jones) was isolated.

The roots of many of the plants were left in the soil and the bed was resown with peas, vetches, red clover, potatoes and sweet peas, on May 19th, but no infection of the plants with *Heterodera* was found when the roots were examined on June 28th and July 12th.

2. A fresh supply of infested soil from Evesham was added to the bed on November 26th, 1932, and it was divided transversely into 26 strips which were sown with the following crops:—

- | | |
|------------------------------|---|
| 1. Potato, Sharpe's Express. | 2. Black Oat, Yeoman. |
| 3. White Oat, Abundance. | 4. Peas, Early Bird. |
| 5. Sweet Peas. | 6. Clover (red). |
| 7. Vetches. | 8. Kale. (A few plants were put in here and there.) |

On April 24th, 1933, the peas were just commencing to pod. White cysts of *Heterodera* were prevalent on the roots of all the pea plants. Bacterial nodules were large and abundant. No other plants were showing infestation.

On May 8th, 1933, the peas were heavily infested with white cysts. The vetches were also heavily infested (Fig. 1), and their leaves were turning yellow. The potatoes, oats, sweet peas and kale were not infested.

The following weeds were all free from cysts: *Brassica Sinapis*, *Capsella Bursa-pastoris*, *Stellaria media*, *Senecio vulgaris*, *Lamium purpureum*, *Atriplex hastata*, *Polygonum aviculare*, *Euphorbia Peplus* and *Urtica urens*.

By June 28th, a few cysts were found on red clover.

Part of the strips were cut down or cleared and a further sowing of vetches and peas, Early Bird, was made on May 15th.

On June 10th, of 52 plants examined, none were infested. On June 28th, of 14 plants examined, 6 were found to be lightly infested.

A further sowing of peas and vetches was made on June 7th,

1933. On June 28th none of the peas were found to be infested, while the vetches were found to be lightly infested.

The plot was cleared of weeds and crop and kept moist during the summer. On October 9th volunteer plants of vetch and potato were examined but no cysts were found.

Conclusions.

The conclusions to be drawn from these greenhouse experiments are as follows :—

- (1) The pea strain was proved to infest vetch and red clover, the former by early May, the latter not until June 28th.
- (2) Twelve common weeds remained free from infestation.
- (3) Potatoes, oats (black and white), sweet peas, and kale all remained free from infestation.
- (4) The absence of infestation of the summer sown plants in 1932 was possibly due to a temperature factor.

Field Trials.

1. Trials in Evesham District.

(a) *Date of Sowing.* This trial was laid down to ascertain whether the date of sowing has any influence on the infestation of peas by the eelworm, since in the field early varieties had seemed to be the most severely infested.

The soil is a heavy clay loam, and had carried a severely infested crop in the previous season. One quart of seed of the variety British Lion was sown in a single row every fortnight, commencing on March 8th. Six sowings were made, the last on May 17th. On July 5th, after the earliest infested row had been removed, another was sown in its place and an adjoining row was also sown where there had been no peas previously in 1933.

It should be noted that all these plants were also infested with foot rot caused by *Fusarium* spp.

It will be seen that all the sowings became infested, the period between sowing and appearance of the female cysts decreasing with the later sowings, from about 80 days in the case of those sown on March 8th to 30 days in the case of those sown on May 17th. Cysts were few when first noticed on the roots but within 7—14 days became very numerous.

The results are given in Table I. :—

TABLE I.—ILLUSTRATING EFFECT OF DATE OF SOWING.

Row No.	Date of Sowing.	Cysts Noted.	Cysts Plentiful.	Notes.
1	March 8th	—	May 25th (after 78 days)	Lower leaves withering. Young pods developing (largest $1\frac{1}{2}$ ins. long).
2	March 22nd	—	May 25th (after 64 days)	Lower leaves withered. Plants in flower.
3	April 5th	May 29th (after 54 days)	June 6th	Cysts visible only on plants with much withered lowest leaves on May 29th.
4	April 19th	—	June 6th (after 48 days)	Leaves in lower parts of plants much withered.
5	May 3rd	June 6th (after 34 days)	June 12th	Cysts just visible on June 6th. Very lowest leaves show withering.
6	May 17th	June 16th (after 30 days)	June 30th	Practically no outward signs of infestation on June 30th.
7	July 5th (following row 1)	August 10th (after 36 days, 1 cyst only)		
8	July 5th (on new ground)	August 10th (after 36 days, cysts few)		

(b) *Varietal Susceptibility*, etc. This trial was carried out on a half acre of heavily infested ground at Charlton, near Evesham. The lay-out consisted of eight blocks of dwarf pea varieties, each unit consisting of Dwarf Defiance, English Wonder, Giant Stride, Hundredfold, King Edward, Lincoln, Prince of Wales, Senator, Sherwood, Stratagem, Surprise, and William Hurst. The arrangement of the varieties was different in each block. Located on the area there were also two blocks containing the following miscellaneous crops : mangolds, oats, potatoes and sugar beets. Pea seed of the variety British Lion soaked in pure cultures of *Bacterium radiculicola* (obtained through the courtesy of Dr. Hugh Nicol, of Rothamsted) was also sown in three further blocks, with control blocks of untreated seed immediately adjoining. Blocks in all

cases were separated by two rows of peas, variety British Lion, which served as controls for the incidence of the pest over the area.

All the crops were sown on April 11th, 1933.

In the light sandy soil, with an unusually dry season, the germination and growth of all the peas on the area was very erratic and thin crops resulted.

Cysts of *Heterodera* were first noticed on the roots on June 1st, when the only sign of disease was a very slight withering of bottom leaves here and there; foot rot was also present.

Examinations were carried out on June 19th and June 26th when careful estimations were made of the growth of the plants in all the rows. Dwarf Defiance was noticeably the best in growth, followed by Stratagem and Surprise. None of the others approached these, all being yellow and stunted. The poorest variety was Prince of Wales. It is possible that varietal differences noted may have been due to some extent to varying degrees of drought resistance as well as to resistance to *Heterodera*.

The plants from inoculated seed showed no improvement over non-inoculated plants, nor was there any noticeable difference in the number of root nodules or in *Heterodera* infestation. Plants lifted on June 10th showed good root systems in both cases, but few nodules.

None of the four other crops grown (potatoes, sugar beets, mangolds and oats) showed any signs of infestation by *Heterodera*, nor was the eelworm found on any of the following weeds:—*Papaver Rhoeas*, *Capsella Bursa-pastoris*, *Medicago* sp., *Xanthium spinosum*, *Lamium amplexicaule*, *Chenopodium album*, *Polygonum aviculare*, *Urtica urens*, *Equisetum* sp.

2. Trials in North Somerset Area.

This centre is a private garden on limestone soil. Failure of peas had been observed for several years and in the previous year, 1932, *Heterodera* had been found.

The main plot consisted of three rows 20 yards long, each planted with four varieties of peas. It had carried heavily infected peas in 1932 and had not had peas for 6 years previous to that time. The ground was dunged in January, 1933, and the seeds sown early in March. The plants appeared normal till the first week in May. By the second week several varieties were showing severe symptoms. On May 25th cysts of *Heterodera schachtii* were found on all the varieties, the following showing yellowing of the lower

leaves :—English Wonder, Dwarf Defiance, King Edward, Best of All, British Lion, Hundredfold, Sherwood and Senator. *Heterodera* cysts were also very numerous on the roots of broad beans on the trial area, but in this case there were no marked symptoms on the above ground parts of the plants.

The plants were again examined on June 12th, 1933, ten to twenty plants being lifted in each case, with the following results :—

<i>Variety.</i>	<i>Heterodera.</i>	<i>Foot Rot.</i>	<i>Height and General Growth.</i>
Dwarf Defiance ..	Moderate	Severe	16 ins. Twisted foliage.
Giant Stride ..	Moderate	Severe	20 ins. This was one of the two worst affected varieties.
Best of All ..	Abundant	Slight	3 ft. 6 ins. Foliage good, cropping well. An outstanding variety.
King Edward ..	Moderate	Severe	2 ft. Bacterial nodules moderate.
William Hurst ..	Very slight	Severe	20 ins. Bacterial nodules few.
British Lion ..	Very abundant	Severe	3 ft. Cropping well. Nodules good. This variety gave good growth.
Hundredfold ..	Slight	Severe	2 ft.
English Wonder ..	Slight	Severe	20 ins. Abundant nodules. Foliage somewhat distorted.
Sherwood ..	Slight	Severe	Very stunted. 16 ins. Foliage dying. Pods distorted. Poor roots. One of the two worst varieties.
Senator ..	Slight	Severe	Nodules good. Height about 2 ft. 6 ins.

Of these varieties the most successful were Best of All and British Lion.

In addition to the main trial an adjoining plot had been sown by the grower and the results may be mentioned here. Onions (heavily manured) had been grown in 1932 and the ground had been limed in autumn of that year and heavily dunged in January 1933. Six pea varieties were sown and in spite of infection with *Heterodera* all the plants were tall, and flowered and podded well. The varieties grown were as follows :—

	<i>Heterodera.</i>	<i>Foot Rot.</i>
Duchess of York	Light	Slight
World's Record	Light	Slight
Princess of Wales	Fairly heavy	Practically none
Bountiful	Light	Slight
Alderman	Very light	Slight
Pilot	Abundant	Very light

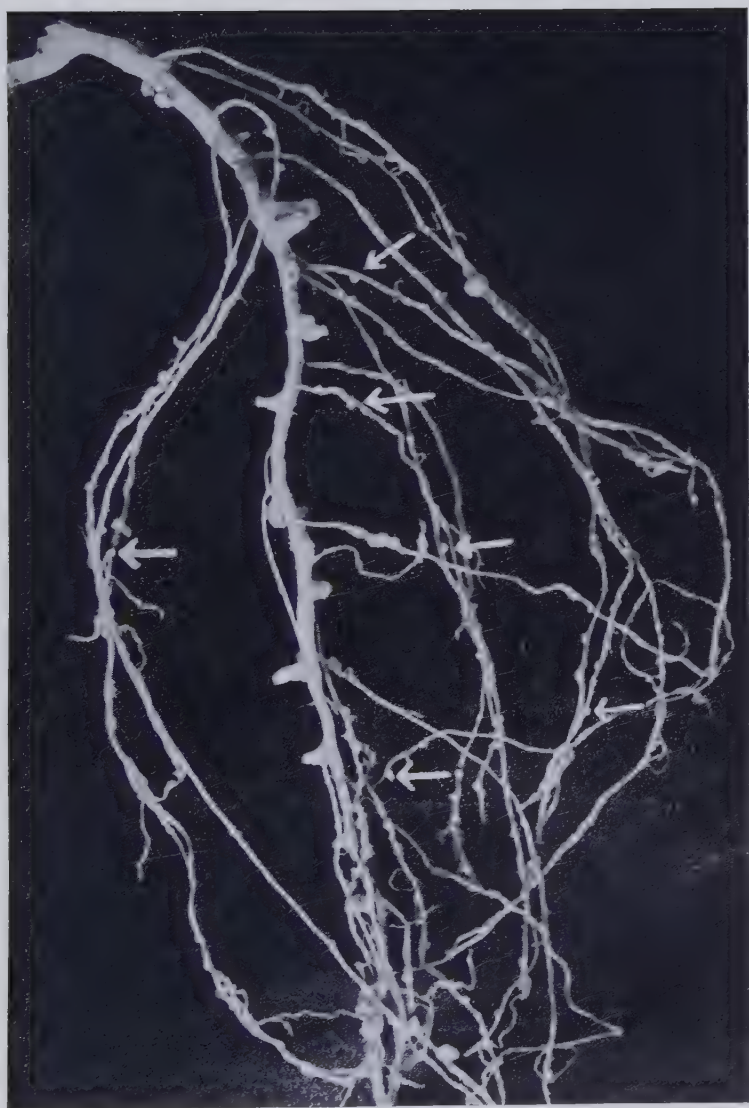


FIG. 1.



FIG. 2.



FIG. 3.

This plot was not so badly infected as the other.

In our trial plot the following other plants were found to be free from *Heterodera*: oats (Yeoman and Abundance), beet, cabbage, sweet pea, potato, *Senecio vulgaris*, *Poa* sp., *Oxalis* sp., *Veronica agrestis*, *Vicia sepium*, *Rumex* sp., and *Stellaria media*.

It should be noted that of the pea varieties Best of All had abundant *Heterodera* but little foot rot, while British Lion had very abundant *Heterodera*. On the other hand, Giant Stride and Sherwood had severe foot rot and the latter had only slight *Heterodera*. This appears to point to the conclusion that foot rot is an important factor in the poor growth of the plants, as is also indicated on the second plot, where growth was good and foot rot slight.

The success of British Lion at this centre is remarkable since this variety is usually severely affected in the Evesham area, although in one or two cases it seemed to stand up well when other varieties were affected alongside. It seems possible that there are several strains of British Lion of varying resistance.

On these plots broad beans were the only other plant which showed *Heterodera* infestation.

The susceptibility of broad beans has already been noted by Edwards, who, in the Ministry's Plant Diseases Summary for July 1933, recorded *Heterodera schachtii* as "very common on peas and beans in Shropshire"; with regard to the non-susceptibility of sweet peas in the above trial and in the greenhouse trials, Jary (4) found that in a garden in the south of England where peas were badly attacked, sweet peas were free from the parasite.

3. Manurial Trial at Evesham, 1932.

The reader is referred to the manurial trial laid down by two of us (Ogilvie and Mulligan) in 1932, and described in the Long Ashton Annual Report for 1932 (7). It was shown that applications of sulphate of ammonia, sulphate of potash and dung at normal rates gave no significant control over the disease, but a slight increase in crop was noted in the case of the two former.

General Observations in the Evesham Area in 1933.

The incidence of pea sickness was quite as severe in the Evesham area in the dry season of 1933 as in the wet season of 1932, both *Heterodera* and foot rot infections being prevalent.

The following table gives an indication of the prevalence of

these two factors in different types of soil, the number of plus signs indicating the approximate degree of infection of the two organisms* and a minus sign indicating absence of *Heterodera*.

TABLE II.—INFESTATION IN RELATION TO SOIL.

Locality.	Variety.	Incidence of <i>Heterodera</i> .	Incidence of <i>Fusarium</i> foot rot.	Soil.
Evesham 1	British Lion ..	++	++	Clay
" 2	" " ..	++	+	Light loam
" 3	Early Bird ..	—	+++	Heavy loam
Charlton ..	British Lion ..	+	++	Light sand
Offenham 1 ..	Early Bird ..	+	++	" "
" 2 ..	" " ..	++	++	" "
" 3 ..	" " ..	?	+++	Heavy sand
" 4 ..	Kelvedon Wonder	+	+	" "
" 5 ..	Senator ..	+	++	Light loam
Hinton Cross 1	Laxton's Superb ..	++	++	Clay
" " 2	Lord Chancellor ..	+	+	"
" " 3	British Lion ..	++	++	"
" " 4	Admiral Beatty ..	++	++	"
Hinton ..	Early Bird ..	++	++	Heavy loam
Childswickham	" " ..	—	+	" "
Norton 1 ..	" " ..	—	++	Clay (?)
" 2 ..	Laxton's Superb ..	—	+	Light loam
" 3 ..	British Lion ..	—	++	Heavy sand
Harvington 1	Thos. Laxton ..	++	+	Heavy loam
" 2	Laxton's Superb ..	++	+	" "
" 3	Springtide ..	++	+	" "
South Littleton	Early Bird ..	++	+	Clay
Badsey ..	British Lion ..	+	+	"
Crophorne ..	" " ..	+	+	Heavy sand
Severn Stoke ..	" " ..	—	+	Light sand
Bretforton ..	Onward ..	+	+	Heavy loam

* + Denotes infection slight, ++ medium, +++ severe.

When these cases are examined, it will be found that there is apparently no correlation between the soil type and the amount of *Heterodera* or foot rot.

As already stated affected areas are often somewhat circular and sharply defined. As an instance we may mention a striking case which occurred near Evesham in 1933, and which is illustrated in Figs. 2 and 3. The variety was British Lion. Most of the field was healthy but there were several circular diseased patches about 10 to 15 feet in diameter. The diseased plants were yellow in colour and about 12—18 ins. high, whereas neighbouring healthy ones were 36—50 ins. high. All the plants were in flower on May 31st, but the healthy specimens bore pods up to 3 ins. in length, while, on the diseased ones, pods were rare and only up to 1 in. long. The diseased patches were sharply defined by the surrounding tall, apparently healthy plants. These, however, also bore *Heterodera*

cysts, though in decreasing numbers outwards from the failure area and finally disappearing. Foot rot was present on nearly every plant and was often severe.

Careful records have been kept of the previous crops on infected ground and it has been found that a three years rotation with non-susceptible crops is insufficient to clear the ground of *Heterodera*.

Broad beans (*Vicia Faba*) were found to be infested with the pea strain of *Heterodera schachtii* in four localities in the area in 1933. This infestation had little effect on the growth of the plant, although in some cases the lower leaves were slightly yellow and the plants were somewhat dwarfed. No crop plants other than Leguminosae were found to be affected in this district or elsewhere. It should be noted here that the potato strain of *Heterodera schachtii* is apparently absent from the Evesham area.

DISCUSSION ON POSSIBLE CONTROL MEASURES.

As a result of the above trials and observations, the pea strain has been proved to be confined to certain Leguminous plants; hence long rotations, exceeding three years between susceptible crops, should be practised wherever possible.

Since vetches are susceptible, there is the possibility that these could be used as a trap crop, and trials with this in view are now in progress.

No pea varieties appear to be immune but a few seem somewhat resistant and these will be tried out further during 1934. In view of the excellent results obtained by two of us (Ogilvie and Mulligan) from the use of formalin solutions against the potato strain of the eelworm, chemical control trials are to be laid down on land infected with the pea strain.

LIST OF NON-SUSCEPTIBLE PLANTS.

Throughout these trials a varying number of economic plants and weeds were accidentally or designedly associated with the infested crop. Fortunately none of these proved to be susceptible to infestation by *Heterodera*. They are set out in botanical sequence below :—

Wild Plants.	Crop Plants.
	PAPAVERACEÆ.
<i>Papaver Rhoeas</i> L. (Poppy).	
	CRUCIFERÆ.
<i>Brassica Sinapis</i> Vis. (Charlock).	<i>Brassica oleracea</i> L. (Cabbage).
	„ „ L. var. (Kale).
<i>Capsella Bursa-Pastoris</i> Moench. (Shepherd's purse).	
<i>Cardamine hirsuta</i> L. (Hairy bitter cress).	

CARYOPHYLLACEÆ.

Stellaria media Vill. (Chickweed).

GERANIACEÆ.

Oxalis sp.

LEGUMINOSÆ.

Medicago sp.

Lathyrus odoratus L. (Sweet Pea).

Vicia sepium L.

COMPOSITÆ.

Senecio vulgaris L. (Groundsel).

Sonchus arvensis L. (Sow Thistle).

Xanthium spinosum L.

SOLANACEÆ.

Solanum tuberosum L. (Potato).

SCROPHULARIACEÆ.

Veronica agrestis L.

LABIATÆ.

Lamium purpureum L.

Lamium amplexicaule L. (Henbit deadnettle).

CHENOPODIACEÆ.

Atriplex hastata L.

Beta vulgaris L. var. (Mangold).

Chenopodium album L. (Goosefoot).

„ var. *Rapa*. Dumort.
(Sugar beet).

Rumex sp.

POLYGONACEÆ.

Polygonum aviculare L. (Knotgrass).

EUPHORBIACEÆ.

Euphorbia Peplus L.

URTICACEÆ.

Urtica urens L.

GRAMINEÆ.

Poa annua L.

Avena sativa L. (Oats).

Poa sp.

EQUISETACEÆ.

Equisetum sp.

SUMMARY.

1. A strain of the eelworm *Heterodera schachtii* has been found to be widely prevalent on the roots of peas throughout the Bristol Province.

2. Severe infestation by this eelworm can bring about yellowing and dwarfing of the plants and a great reduction in yield.

3. Infested plants are usually affected also with foot rot brought about by soil inhabiting *Fusaria*. The foot rot may cause the plants to die off prematurely.

4. The pea strain of *Heterodera* has been proved to infest also broad beans, vetches and red clover, but not potatoes, man-golds, sugar beets, kale, cabbage, sweet peas, oats or any of 23 common weeds. Broad beans were found to be commonly infested in field plantings.

5. Most pea varieties are highly susceptible, but a few appear to be somewhat resistant.

6. The time from sowing of the seed to emergence of the first female cysts varied from approximately 80 down to 30 days according to the date of sowing.

7. The use of sulphate of ammonia, sulphate of potash and dung had no remedial effect.

8. A rotation which included three years free from peas or beans was insufficient to free the soil of infection.

9. The trouble occurred almost equally on heavy and light soils and in wet and dry seasons.

10. As a control measure, long rotations free from susceptible leguminous crops are suggested. The use of resistant varieties, trap crops and chemical measures is to be further investigated.

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ILLUSTRATIONS.

FIG. 1. Vetch plant showing cysts of *Heterodera schachtii* on the roots.

FIGS 2 and 3. "Pea sickness" (*Heterodera*+foot rot) at Lenchwick, near Evesham, May 31st, 1933.

THE EFFECT OF FORMALIN ON POTATO "SICKNESS."

By L. OGILVIE.

In the course of efforts to control potato "sickness," associated with the nematode *Heterodera schachtii*, various chemicals have been used. Satisfactory results have been previously reported from the use of drained creosote salts, naphthalene and stinking animal oil*, but further trials have shown that the effects are very variable, and in many cases no appreciable benefits have followed.

The object of this note is to draw attention to the consistent results which have been obtained from the use of formalin. These are summarised in the following tables:—

A. YEAR 1930.

CENTRE ASHTON GATE.

Treatment.

Yield from Plot of 9 sq. yds.

- | | |
|---|----------|
| 1. Formalin (4½ gallons 1-50 formalin soln. per sq. yd. watered on) | 13.7 lb. |
| 2. Formalin (do., but plot covered over for 2 days) | 14.4 lb. |
| 3. Control plot. No treatment | 6.6 oz. |

B. YEAR 1931.

CENTRE FISHPONDS.

Treatment.

Yield from Row of 28 yds.

- | | |
|--|--------|
| 1. Formalin (4½ gallons 1-50 formalin soln. poured into furrows, 1½ gals. per yd., which were then covered in) | 70 lb. |
| 2. Control plot. No treatment | 20 lb. |
| 3. do. do. | 20 lb. |

C. YEAR 1933.

CENTRE NAILSEA.

(a) *Treatment.*

Observations.

- | | |
|--|---------------------------------------|
| 1. Formalin (1-50 soln. poured into furrows, 1 gal. per yd., which were then covered in) | Growth strong. Plants 2 ft. high. |
| 2. Control plot. No treatment | Growth very weak. Plants 14 in. high. |

(b) *Treatment.*

Yield from Row 88 ft. long.

- | | |
|--|---------|
| 1. Formalin (1-50 soln. poured on row, 1 gallon per yd. No furrow was dug, and treated rows were not covered over) | 116 lb. |
| 2. Control plot. No treatment | 75 lb. |

* For the literature on chemical treatments the reader is referred to Goodey's "Plant Parasitic Nematodes" (*Melhuén*).

In every case the formalin was applied approximately a fortnight before the tubers were planted.

The effects of all these treatments were very noticeable in the vigorous growth of the plants on treated soil, compared with very poor growth on untreated soil alongside. It should be noticed that the number of cysts was in all cases reduced, but in no case was there a complete absence of cysts on the roots of the treated plants.

Applications of the following chemicals have produced no appreciable control in experiments carried out at the same centres from 1930 to 1933 : sulphur, corrosive sublimate (1-2000), pyroligneous acid and mixed cresols.

It is not suggested that formalin treatments as described above are economic measures. It is emphasised, however, that, in the writer's experience, only the formalin treatments have given consistently good results. It is perhaps just possible that some modification of the formalin treatment might be of economic value.

The writer wishes to acknowledge the co-operation of several other members of the staff in these trials.

A SUMMARY OF RECENT INVESTIGATIONS ON APPLE SCAB.

By R. W. MARSH.

The purpose of this article is to give in non-technical language a digest of the more important recent papers on apple scab, special references being made to those points on which requests for information are most frequently received by the writer.

Scab Infections on the Shoot.

The ability of the scab fungus to affect apple shoots has long been recognised, but certain further details of this process have recently been published. Attention has been drawn to the existence of infections on spur wood (Salmon and Ware, 1931 ; Weston and Petherbridge, 1933) as well as on the extension shoots. On the latter it has been shown (Marsh and Walker, 1932) that the fungus infects the young shoots during their summer growth period, gaining an entrance only near the tips where bark formation has not taken place. With the development of bark the external spread of the infection on the shoot is arrested but the fungus continues to extend beneath the bark, at the same time increasing in thickness until a minute cushion is formed. By forcing off the overlying tissue, the outer face of this cushion becomes exposed to the air and, on this, spores continue to be formed for many weeks. Beneath the infection, however, the cells of the shoot give rise to a cork barrier which may isolate the diseased portion entirely. This barrier formation takes place only during the growing season ; if the fungus is not successfully cut off during the summer it continues its extension beneath the bark during the winter unimpeded and forms new infection cushions around and below the original point of entry. (See also Moore, 1932.)

These subsidiary infections may be seen bulging up the bark of the new shoots during February and March, the majority remaining covered by an unbroken bark layer until late March and April when the bark over the infections splits open. During April and May these newly-exposed subsidiary infections produce spores in great numbers. In dry weather the spores remain attached, but during rain they become freed and are dispersed by being washed,

splashed or blown in drops of rain. They are not therefore spread over any great distances; a few may be carried 30 feet but the majority, very much less.

From the latter half of May onwards the subsidiary infections are, in their turn, cut off by cork barriers and the infected area then falls out entirely. With very rare exceptions, scab does not persist on a shoot later than the summer following the formation of that shoot. In certain apple varieties (*e.g.* Cox), wood of three years old and more may be found deeply pitted and is then commonly termed "scabbed wood." These pits, however, simply represent the sockets from which the scabbed tissues have fallen and such shoots do not contain any living material of the scab fungus.

Spread of Infection in Spring.

Returning to a consideration of the spore dispersal in spring from the young shoots showing active spore-producing infections, it is found that this dispersal continues during wet weather over the whole period of opening of the blossom buds. It has been shown (Marsh and Walker, 1932; Weston and Petherbridge, 1933) that spores from the shoot infections reach the unfolding leaves and blossoms in considerable numbers during April and May. Whether these spores germinate depends primarily on the number of hours during which they remain wet. (Keitt and Jones, 1926). At 42° F. the minimum period for germination is 18 hours in water; at 49°, 11 hours; and at 59°, 8½ hours. These times need not be continuous; for example, two 6-hour wet periods at 59° with an intervening dry period would suffice for germination.

If the conditions for germination are fulfilled, the spore lying on the surface of a leaf puts out a thin-walled outgrowth which will grow into the leaf tissue unless the leaf has reached an age when the cuticle defies penetration. The time of attaining this impenetrability depends mainly on the variety of the leaf. If the fungus successfully enters the leaf its further progress will be determined no longer by external factors but will be dependent on its own vigour and on the conditions existing within the tissues of the leaf.

It has now been shown (Johnstone, 1931; Wiesmann, 1931) that there exist definite forms of the scab fungus, some more virulent than others, and also that certain varieties of apples are much more susceptible to attack by scab spores from infections on the same variety than by those from other varieties. (This fact may account for the observed gradual geographical extension of scab

susceptibility in a variety such as Bramley's Seedling.) A scab spore germinating on a leaf of a variety to which it is not infective will penetrate the leaf, but make little subsequent growth. Similarly, certain nutritional conditions of the leaf affect the growth of the scab fungus within the leaf tissues. Leaves of trees growing under low nitrogen conditions will not support any extensive growth of the scab fungus. On the other hand, the leaves of potash-deficient trees provide a favourable environment for the scab fungus, and its growth and fruiting period on such leaves are prolonged.

The time of appearance of a visible scab spot on a leaf is from two to three weeks after the germination of the spore from which the infection arose. On these leaf spots, spores are produced in great numbers, a spot of $\frac{1}{8}$ th inch diameter carrying about 6,000 spores. It was found (Keitt, 1926) that, if all the mature spores from such a pustule were washed off, a new crop would be produced in 24 hours and that, when this process was repeated five times in a fortnight, the number of spores produced on each successive occasion remained essentially undiminished. The spores from the scabbed leaves are the source of infections of the new shoots and fruit, and it is therefore a first principle of scab control to prevent from the outset the establishment of the fungus on the leaves.

The Times for Spraying.

It has been mentioned above that, where trees are bearing scabbed shoots, the young leaves are liable to intercept spores from this source from the time when the buds first open until the blossoming period. Other factors determining infection have been cited and it will be realised that, with a scab-susceptible variety, the occurrence of wet periods between bud-opening and blossom time will be the most potent influence in determining the amount of protection, in the form of spray applications, to be given to the unfolding leaves. In the Bristol Province, the risk of a wet period occurring before the pink blossom stage is sufficiently great to justify the recommendation to give scab-susceptible varieties at least two sprays before blossoming: one at the "green-flower" stage and the other at the "pink" stage. The green-flower stage is chosen as a compromise between protecting the leaves at their earliest appearance and protecting a reasonable area of leaf surface at one spraying. By inserting into the programme an additional spray application before the green-flower stage the protection afforded is increased, but it is not advisable to give this earlier spray *as a substitute* for the green-flower application.

In the East of England, Cheal (1933) has shown that in the

Wisbech area in 1932, two pre-blossom and one post-blossom sprays on Worcester Pearmain resulted in a crop 64 per cent. scab-free, while one pre-blossom and two post-blossom sprays gave 33 per cent. scab-free fruit. Even in the dry season of 1933 the application of the spray at the green-flower stage was advantageous, although the benefit was much less marked than in the wet summer of 1932. Experiments carried out near Cambridge in 1932 (Weston and Petherbridge) showed that one pre-blossom and two post-blossom sprayings gave a good control of scab on trees not bearing shoot infections. On trees with shoot infections this programme required strengthening by an additional pre-blossom spray at the green-flower stage.

Spray Damage.

In drawing up a programme for post-blossom spraying, the deciding factor is that of spray damage. In pre-blossom spraying, serious spray damage is rare, the only recorded examples (Moore, 1930) being the russetting of the fruit of Cox when the trees were sprayed in the pink stage with Bordeaux mixture, and a reduction in crop of Stirling Castle trees sprayed at the pink stage with 3 per cent. lime sulphur. After blossoming, however, loss of foliage and fruit may occur when a sulphur-containing spray is applied to any of the following varieties :—Stirling Castle, Lane's Prince Albert, Newton Wonder, Rival, Belle de Boskoop, St. Everard and Cox's Orange Pippin. Of these varieties, Stirling is highly sensitive to sulphur damage, and Lane comes next in susceptibility. Cox is more resistant and may be given post-blossom treatments with weak lime-sulphur sprays.

There is also a wide range of varieties which are damaged when copper-containing sprays such as Bordeaux mixture are employed for post-blossom applications. Here the damage takes the form of serious fruit russetting and cracking on Cox and James Grieve, and less conspicuous russetting on Worcester, Stirling, Rival, Beauty of Bath, Gladstone, Lane, Derby and Newton.

It will be noted that certain varieties are both sulphur-sensitive and copper-sensitive, and it is not possible at present to recommend any spray for post-blossom treatment of such a variety as Stirling. It follows that when Stirling is interplanted with other varieties, serious difficulties arise in spraying practice, and this is a point calling for consideration when new plantations are planned.

Choice of Fungicide.

Among the sulphur-containing fungicides the material which has been most employed for scab control is lime sulphur. It is

usually purchased as a manufactured product containing 24 to 25 per cent. (weight in volume) of sulphur in the polysulphide state. As a rough figure for comparative purposes, it can be said that a gallon of lime sulphur concentrate after dilution and subsequent drying deposits approximately $2\frac{1}{2}$ lb. of finely-divided sulphur. The spray deposit from a lime sulphur application, if allowed to dry on the leaves, is very resistant to removal by rain. It has also been shown (Hamilton, 1931) that lime sulphur at 1 in 40 strength possesses, in addition to its protective effect, the ability to prevent successful development of scab infections even if applied up to three days *after* the spores have germinated on the leaves. Furthermore, if applied to infections already established and bearing spores, it will inhibit further spore production and may "burn out" the scab spot entirely.

The proprietary "colloidal" sulphurs* are, in terms of cost per sulphur content, much more expensive than lime sulphur. When used, therefore, at a strength which reduces the cost of the diluted wash to that which the grower has been accustomed to pay for lime-sulphur sprays, the effect is the production of a fluid of low sulphur content. While such a mixture is less liable to cause spray damage, at the same time it gives less efficient scab control. The colloidal sulphurs may have some application in post-blossom scab spraying, but are not suited for use as pre-blossom washes.

The sulphur dusts have the merits of quickness and convenience of application when suitably quiet weather conditions occur. The main disadvantage of a dust deposit lies in the fact that it is much less resistant to rain than the deposit from a lime sulphur spray. Half an inch of rain (Hamilton, 1931) is sufficient to reduce seriously the protective qualities of an application of dusting sulphur.

In the group of copper-containing materials Bordeaux mixture remains as the cheapest means of applying copper as a spray. As noted above, however, the use of Bordeaux mixture in post-blossom spraying is more limited by spray damage considerations than is that of lime sulphur.

The "colloidal" copper spray fluids correspond to the colloidal sulphurs in being relatively expensive sources of the active material—in this case, copper. It has been suggested (Marsh, 1932) that a colloidal copper spray might be used for the post-blossom application to Lane's Prince Albert, thus providing a measure of summer

* Strictly speaking, these products are sulphur suspensions, since they contain a large proportion of particles above the size of those found in a true colloidal preparation of sulphur.

protection to this sensitive variety without causing spray injury. Copper-lime dusts are also being used for scab control, but no reports of trials made on apples in this country with those dusts have yet been published.

Suggestions have been put forward that certain substances should be incorporated in scab control sprays with the object either of reducing spray damage or of increasing the efficiency of the spray. The addition of aluminium sulphate has been claimed as a method of obviating sulphur damage, but these claims have not been substantiated in trials made in this country (Marsh, 1930 ; Martin, 1930). Gelatine has been advocated to increase the sticking power of lime sulphur, but where comparative trials have been made (Keitt, 1926 ; Moore, 1931) it has been shown that the fungicidal effect of the spray was impaired by the addition of gelatine. The use of wetting and spreading agents with lime sulphur or Bordeaux applications is called for when these sprays are combined with an insecticide such as nicotine, but it has not been shown that any advantage in toxicity is gained by using a wetting agent in a wash designed for scab control alone.

Spray Programme.

In devising an effective programme against apple scab, the use of lime sulphur throughout will reduce complications to a minimum. All varieties to be sprayed against scab should be given an application of lime sulphur 1 in 30 at the pink stage. Varieties specially susceptible to scab (*e.g.* Cox, Worcester, Grieve) need an additional pre-blossom spray at the green-flower stage. After blossoming, badly scabbing varieties should receive a 1 in 60 lime sulphur spray at petal-fall, with the exception of Cox, which, being somewhat sulphur-sensitive, should be given this spray at 1 in 100 strength. Those sulphur-sensitive varieties which are more resistant to scab are best left unsprayed after blossoming. The suggested scheme for a group of six common commercial varieties is thus :—

		<i>Green-flower stage.</i>	<i>Pink stage.</i>	<i>Petal-fall stage.</i>
Cox	..	L.S. 1 in 30	L.S. 1 in 30	L.S. 1 in 100
Worcester ..	..	L.S. 1 in 30	L.S. 1 in 30	L.S. 1 in 60
Grieve	..	L.S. 1 in 30	L.S. 1 in 30	L.S. 1 in 60
Lane	..	L.S. 1 in 30	L.S. 1 in 30	—
Newton	..	L.S. 1 in 30	L.S. 1 in 30	—
Bramley ..	..	—	L.S. 1 in 30	L.S. 1 in 100

Where Cox and Worcester are interplanted it will probably be found simpler to spray the whole block with lime sulphur at 1 in

100 strength at petal-fall and then repeat the treatment three weeks later. In general, however, the effect of an additional spraying after the petal-fall stage is slight compared with that of the other spray applications.

The relation of the scab spraying programme to the application of insecticides and the possibilities of combined insecticide-fungicide sprays have been recently dealt with (Kearns, Marsh and Pearce, 1932; Austin, Jary and Martin, 1932) and will not be further considered here. Similarly the subject of spraying technique is omitted, since it has been summarised elsewhere (Swarbrick, 1932). One point of spraying technique may, however, be mentioned in conclusion. It is essential in scab control to make thorough applications; special attention should be paid to the spraying of the inner portions of the tree, and the amount of spray used for each application should be approximately 300 gallons per acre.

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A NOTE ON A STRAWBERRY DISEASE RESEMBLING THE AMERICAN "CRINKLE."

By L. OGILVIE, T. SWARBRICK and C. R. THOMPSON.

A peculiar strawberry disease, commonly occurring in commercial strawberry plantations in the south-west of England, has been under observation by us for more than five years.

On May 9th, 1928, one of us (L.O.) visited a plantation of the Royal Sovereign variety in the county of Worcestershire in which the plants were markedly diseased. The following is a copy of notes recorded at the time. "Large, elongated areas in the fields contained plants whose mature leaves were abnormally small. The younger leaves of these plants were pale in colour, sometimes mottled, and characteristically much puckered. Dotted over the leaves were reddish or purplish markings, which eventually dried out into necrotic spots. These areas were surrounded by narrow yellow margins. Affected plants were dwarfed and flattened."

It has since been observed in further cases that the symptoms may vary greatly in intensity from plant to plant. Often only a few leaves may bear spots, which may give rise only to a very slight distortion. The spots originate as minute, almost transparent, points. Subsequently these enlarge somewhat and in the centre of each a reddish or purplish spot appears. The areas increase still further and finally dry out into the brown necrotic patches described above. A marked "clearing of the veins" is often noticed, a symptom characteristic of certain virus diseases, such as "aster yellows." The accompanying illustrations give a good idea of the symptoms of the disease.

A feature of the pathology of the strawberry is the similarity of the symptoms of many distinct diseases. Thus the spotting we have described may be readily confused with that brought about by strawberry mildew, or to a lesser extent with that caused by the leaf spotting fungi *Mycosphaerella Fragariae* and *Septoria* (? *Stagonospora*) *Fragariae* (3). In the case of these, however, fungus mycelium may be found easily in the spots, which do not give rise to any distortion.



PLATE I.

A STRAWBERRY DISEASE RESEMBLING THE AMERICAN "CRINKLE."

Symptoms on leaves of Royal Sovereign.

Affected leaves showing mottling and distortion. Compare with leaf from healthy plant.



PLATE II.

A STRAWBERRY DISEASE RESEMBLING THE AMERICAN "CRINKLE."

Symptoms on leaves of Royal Sovereign.

Affected leaves showing necrotic spots and distortion. Compare with leaf from healthy plant.



PLATE III.

A STRAWBERRY DISEASE RESEMBLING THE AMERICAN "CRINKLE."

Affected plant of Royal Sovereign

Again the injuries caused by aphides, *Tarsonemus* mites and red spider are somewhat similar, but can be readily distinguished by the trained eye.

The "yellow edge" disease recently described by Harris (2), which may or may not be distinct from the "aphis plant" of Briton-Jones and Staniland (1), brings about dwarfing and flattening of the plant, but no distortion of the leaves.

In August, 1932, a paper was published by Zeller and Vaughan (5) in which they described a disease of strawberries new to the United States, to which they gave the name "crinkle." Full details regarding the disease have been given by Zeller (6) in a recent paper. The symptoms of this disease are identical with those outlined above.

Vaughan (4) and again Zeller (6) have shown that this disease is transmitted in the United States by a common aphis, *Myzus fragaefolii*, and therefore falls into the category of virus diseases. It is of some interest that this aphis is now thought to be identical with the common English aphis *Capitophorus fragariae* (7).

Further field observations and laboratory work on this disease are at present in progress at Long Ashton. We invite communications from growers who may suspect the presence of the disease in their plantations.

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PROGRESS REPORT ON VEGETABLE DISEASES.—V.

By L. OGILVIE and B. O. MULLIGAN.

INTRODUCTION.

The following report deals with work on Vegetable Diseases in the Bristol Province, and especially in the Evesham area, carried out during the season 1932-33, and is a continuation of those previously published (2, 4, 5, 6).

Short popular articles dealing with groups of vegetable diseases are being published in the Worcestershire Agricultural Bulletin (7), while a summary of a lecture given to the Horticultural Education Association in 1932 was published in its Year Book for 1932 (3). Many of the results of our investigations have been incorporated in the recent bulletin on Vegetable Diseases (No. 68), issued by the Ministry of Agriculture and Fisheries.

We continue to be in very close touch with market gardeners in Worcestershire and throughout the Province, and wish here to acknowledge the facilities for field trials readily granted by many. Twenty-three field trials were laid down during the season.

For the purpose of experiments on soil borne diseases twelve plots, each measuring six feet square, have been laid out at the Research Station. These were bounded by zinc sheets three feet deep. The plots have been inoculated with pure cultures of certain soil fungi and are proving of much value.

Dr. C. L. Walton, the Advisory Entomologist, has assisted us in work on the pea strain of *Heterodera Schachtii* and its relation to pea "sickness," and these observations are published in a separate paper in this Report.

ASPARAGUS DISEASES.

Asparagus Rust.

Specimens of asparagus rust (*Puccinia Asparagi*) Plate I, Fig. 1), were forwarded to us on September 29th, 1933, from Halesworth, Suffolk, by Mr. A. B. Thorn, County

Instructor in Horticulture, Ipswich, and this stimulated further inquiry, with the result that the rust was found by Dr. Dillon Weston and others in at least 23 different localities in the Eastern Counties. Search in the Evesham area has resulted in the discovery of one case only, on October 31st (when the "bower" was just about to be cut down and burned), and in this instance only a few plants were lightly infected. Growers are advised, however, to keep a careful lookout for the orange pustules of the fungus on the young shoots early next season and, if these are found, to report the occurrence to us at once.

As has been mentioned previously in these reports, asparagus rust was probably present in the Evesham district early in the century, but there has apparently been no recorded reference to it in England since 1897. Previous occurrences of the disease have been referred to in a recent paper by the Ministry's Plant Pathological Laboratory (1). G. Abbey apparently recorded it as disastrous in Worcestershire in 1895, and Sir Rowland Biffen has reported that he has specimens gathered by him in 1899 at Evesham, while a discerning grower in the Evesham district informed Mr. R. C. Gaut that asparagus rust crippled the growth there so much in 1904, 1905 and 1906 that scores of acres were ploughed up.

Mr. E. Mustoe, of Badsey, informed the senior writer in 1928 that rust was prevalent in the Evesham area some 30 years ago, and occurred there for 4 or 5 years in succession. The disease was very destructive, causing the leaves to fall off.

The Old English asparagus grown at Evesham came to be called Bedenham's Purple Giant. Towards the end of last century strains of Palmetto were introduced and this proved somewhat resistant to rust. The Evesham strains of asparagus cannot now be assigned to any one variety, but are a mixture of Bedenham's, Palmetto and Conover's Colossal, although plants almost true to the last two varieties may often be found in the area. For a full discussion of the various strains the reader should consult the recently issued bulletin on Asparagus (No. 60) issued by the Ministry of Agriculture.

It is probable that the rust has been present in England and possibly in Worcestershire in non-epidemic form for many years, and that the hot and dry summer of 1933 was favourable for its spread.

The rust first appeared in the United States in 1896 and caused very great damage. Conover's Colossal, the most popular variety of asparagus at the time, was extremely susceptible and was soon replaced by strains of Palmetto which proved more resistant.

This group was not suitable for canning on account of its coarseness and colour. Other resistant varieties were therefore worked up by breeding, the most important of these being known as Martha and Mary Washington. It may be noted that the latter was tried out several years ago at Evesham, but did not appear to have much lasting power. Further trials of this and other selected strains are being carried out by Mr. R. C. Gaut and the Worcester Agricultural Committee.

It is hoped that the rust will not occur to an epidemic extent next season, but if the "cluster cup" stage is discovered in the early summer, affected "grass" should be cut and destroyed. Dusting with sulphur may also be resorted to.

Violet Root Rot (*Rhizoctonia Crocorum*) (Plate I, Fig. 2).

Two more infected areas have been discovered, making a total of ten known infected fields in Worcestershire.

Control Trials. A number of control trials were laid down in 1931 and 1932, with the results for 1933, here summarised:—

1. *Formalin.* An infected plot about 700 sq. ft. in area was treated on September 17th, 1931, and again on September 12th, 1932, with 2 per cent. formalin solution, at the rate of approximately $\frac{1}{2}$ -gallon per square yard. No old asparagus roots were removed before the treatment, and the ground was not covered over in any way after treatment. The plot was replanted with asparagus seedlings in the spring of 1933.

On October 5th, two young plants in one row showed the presence of the fungus on the roots, but the others remained clean.

2. *Mercuric Chloride.* In this case an attempt was made to stop the spread of the fungus outwards by removing all apparently diseased plants, digging a trench about 1 ft. wide and 1 ft. deep around the edge of the infected area, and watering the soil around the roots of the remaining plants and the trench itself thoroughly with mercuric chloride 1 in 1600. These treatments were carried out on September 14th, 1932. No further spread of the disease along these treated rows was observed throughout 1933.
3. *Pyroligneous Acid.* In this plot the affected roots were dug up thoroughly and the soil watered with 4 per cent. pyroligneous acid at the rate of about 1 gallon to 2 or 2 $\frac{1}{4}$ sq. ft. of soil. One row was treated a second time

on March 23rd, 1933. Four rows on the plot were planted with 60 one-year-old asparagus seedlings on April 5th. Active mycelium was found plentifully both in treated and control rows on August 31st; the roots of many plants were found to be infected and symptoms were apparent in the yellowing foliage.

4. *Copper Sulphate*. In this plot and the two following all diseased roots were dug out, the ground forked over lightly and the chemicals applied on September 7th, 1931, and October 10th, 1932. A copper sulphate solution (1 lb. to 2 gallons) was applied at the rate of about 1 gallon per 3 sq. ft. Four infected plants were found on the plot on August 30th, and five by September 19th.
5. *Cresylic Acid*. A 1.5 per cent. cresylic acid solution was applied at the rate of about $1\frac{1}{2}$ gallons per sq. yard. Four infected plants were found on the plot on August 30th, and nine by September 19th.
6. *Chloride of Lime*. Chloride of lime was applied in powder form at the rate of about 1 lb. to 12 sq. ft., and thoroughly mixed with the soil. Two infected plants were found on the plot on August 30th, and thirteen by September 19th, 1933.

Only one of these treatments, viz. mercuric chloride 1 in 1600, appears to have been at all effective and this must be tried further before it can be recommended.

Zopfia rhizophila.

Four three-year-old asparagus plants, each with 8 to 14 roots up to 5 mm. in diameter, were washed thoroughly, soaked in 1-1000 mercuric chloride for five minutes, and then washed in distilled water. They were then placed in sterile crystallising dishes and inoculated with cultures of *Zopfia* from three sources. The plants were kept alive in the dishes for ten months, but there was no spread of the fungus from the points of inoculation.

DISEASES OF DWARF (FRENCH) BEANS.

Halo Blight (*Bacterium Medicaginis* var. *phaseolicola*).

Some of the varieties found from our 1931 and 1932 trials to be considerably resistant are now being planted commonly in the Evesham area with satisfactory results.

There was very little spread of the disease in the field in 1933, owing to the unusually dry season, but some was noticeable in early July, correlated with heavy rain on June 15th and 20th.

A further case of diminution of primary infection following the use of old seed was noticed. A stock of Canadian Wonder seed gave 92 per cent. infected plants in 1932. In 1933 seed from the same stock gave 2 per cent. infected plants, but the germination was only about 40 per cent.

The value of early roguing for control of the disease was again evident.

Foot Rot.

Resistance Trials. A further trial of dwarf bean varieties for resistance to foot rot, caused by *Fusarium Solani* var. *Martii* (App. et Wr.) Wr. (= *F. Martii* var. *Phaseoli* Burkh.), and possibly other *Fusaria*, was laid down at Offenham, near Evesham, in 1933. There were two plots. The first had borne a severely affected crop of dwarf beans in 1931, followed by carrots in 1932. The soil is light and sandy. The previous history of the second plot was not known. It is about 50 yards from the first plot and on the same type of soil.

One and a half pints of seed each of the following varieties were sown on April 26th and 27th: Abundant, Black Prince, Black Wonder, Early Prolific, Magpie, Ne Plus Ultra, Superlative and Unrivalled. These varieties are those which have been found to be satisfactorily resistant to halo blight.

The trial was considerably interfered with by bad germination in the case of several varieties and by the effects of drought, but the following results are of some interest.

Typical symptoms of foot rot were noticed in Early Prolific on June 10th, the lower leaves commencing to turn yellow and the base of the stem and the roots showing the usual reddish discoloration. By July 3rd Ne Plus Ultra also showed typical stem and root lesions.

On July 29th, on Plot 1, typical yellowing symptoms were prevalent in Early Prolific, the most healthy varieties being Superlative, Black Wonder, Abundant, and Unrivalled, in that order. On Plot 2 all the plants were apparently healthy.

On August 9th, on Plot 1, all the varieties appeared yellow from foot rot and drought combined, but the lower half of the row of Black Wonder was greener than the others.

On August 30th, on Plot 2, the disease was present but apparently doing little damage. The most severely affected variety was Early Prolific, followed by Ne Plus Ultra, then Abundant and Black Wonder. The most healthy varieties were Superlative and Magpie.

We may conclude that the susceptibility to foot rot of the variety Early Prolific has been confirmed, and found to be greater than any other of the varieties tried. Ne Plus Ultra probably follows in susceptibility, but there are indications that Superlative, Black Wonder and possibly other varieties are somewhat resistant, and these should be tried again.

Possible Transference on Seed. To ascertain whether the foot rot *Fusaria* are commonly carried on the surface of the seeds, 20 seeds of each of the following varieties, collected from the trial ground, were placed on damp filter paper in petri dishes : Abundant, Black Wonder, Canadian Wonder, Early Prolific, Ne Plus Ultra. No *Fusaria* developed in any case.

General Observations. The following varieties were found to be rather severely affected in commercial plantings in the Evesham area in 1933 : Abundant, Early Prolific, Keeney's Stringless Refugee, and Leicester Wonder.

Observations confirmed the opinion expressed in previous reports that the disease can remain active in the soil for many years without the presence of dwarf beans.

DISEASES OF RUNNER BEANS.

Halo Blight.

The occurrence of halo blight, caused by *Bacterium Medicaginis* var. *phaseolicola*, on runner beans was recorded by us in our 1932 report, but it was there stated that the disease caused little damage to this host.

On June 13th, 1933, our attention was drawn to a large planting of the variety Prizewinner, part of which was very severely infected with halo blight and part practically healthy. The affected part showed severe seedling blight, severe leaf spotting and systemic infection. It was found that to aid germination the grower had soaked part of the seed in warm water for six hours prior to planting, and this soaked seed gave rise to the severely infected plants. Three other varieties sown alongside showed no disease whatever.

A quantity of the Prizewinner stock which had produced diseased plants was obtained from the grower and part was soaked in the

same manner and sown at the Research Station alongside unsoaked seed. The soaked seed gave 105 infected plants out of 136, *i.e.* 77 per cent. infected, while the unsoaked gave 16 infected plants of 91, *i.e.* 18 per cent. infected. It thus appears that soaking of infected bean seeds in this way, a fairly common procedure in the Evesham area, is likely to increase the amount of disease in the resulting plants, if the seed is infected.

Wilt.

In our last Progress Report mention was made of the occurrence in the western parts of Worcestershire of a wilt disease of runner beans, associated with a species of *Fusarium* (Plate II, Fig. 2). This disease has now been rather fully investigated.

The symptoms of the disease may first appear on the primary pair of entire leaves, the margins of which turn a yellowish green colour, followed by wilting and commonly withering of parts of the leaf-blade, which becomes dry and brittle. The margins of the later compound leaves often roll inwards, and the leaflets droop. These symptoms appear progressively in the younger leaves, till finally the whole plant withers and dies. Sometimes the primary leaves may show only a slightly paler colour than normal, with little or no wilting; in these cases wilting and shrivelling follows on the trifoliate leaves.

If the stem and roots are cut longitudinally, a dark brown discolouration of the vascular system is seen, often traceable up into the young leaflets and down into the main and lateral roots.

The causative fungus apparently enters the plant in the region of the hypocotyl, and is usually very abundant in the interior of the vessels.

The disease is known from three localities in the Kempsey area of Worcestershire and one near Pershore. It causes considerable loss, aggravated by the fact that the crop is grown annually, often with a short or even no rotation.

Resistance Trial. A large variety resistance trial was laid down on a badly infected ground at Kempsey in 1933. The preceding crop was sprouts. On April 27th, 23 stocks of seed were sown in the order shown in the accompanying table (Table I). Each row was 24 ft. long, the rows were 2 ft. apart and the plants 9 in. apart.

Germination was poor in several varieties as will be seen from the first column of the table. By June 7th, wilt was appearing all over the plot, as well as in normal sowings on nearby land.



PLATE I. FIG. 2.

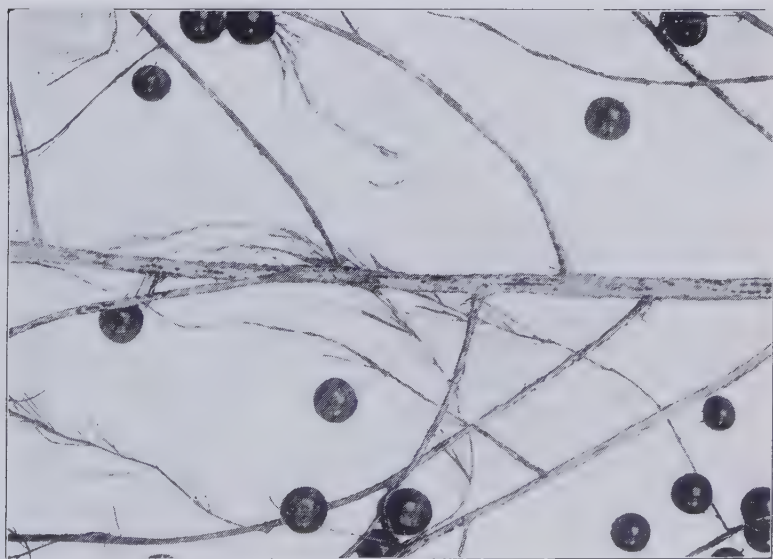


PLATE I. FIG. 1.



PLATE II. FIG. 1.



PLATE II. FIG. 2.

TABLE I.
INFECTION COUNTS AT RUNNER BEAN TRIALS, KEMPSEY, 1933.

<i>Variety. (Origin of Seed indicated in Brackets).</i>	<i>Total No. of Plants.</i>	<i>Infected 27.6.33.</i>	<i>Infected 13.7.33.</i>	<i>Infected 5.10.33.</i>	<i>Clean 5.10.33.</i>	<i>Per cent. Clean.</i>
3 ROWS OF EACH.						
Marvel. Painted Lady (S)	84	21	25	19*	6	24
A.I. (S)	79	31	24	18	7	28
Emperor's Master (Ca.) ..	76	18	20	19	6	24
Mammoth White (Sn.) ..	83	12	15	12	13	52
Ne Plus Ultra (H) ..	81	22	31	20	5	20
" " " (S) ..	68	21	21	14	11	44
White Prizewinner (Cl.) ..	68	14	24	15	10	40
Scarlet Prizewinner (S) ..	68	15	21	16	9	36
Hollington Scarlet (S) ..	92	29	25	21	4	16
Elephant (Ca.) ..	90	27	27	19	6	24
Best of All (S) ..	66	30	28	21	4	16
Hackwood Park (S) ..	82	40	40	21	4	16
Abundance (Ca.) ..	85	35	27†	16	9	36
Champion (S) ..	80	25	25	18	7	28
Unicum (H) ..	96	35	33	22	3	12
Veitch's Mammoth (Sn.) ..	77	37	32	18	7	28
Sutton's Scarlet (Sn.) ..	90	17	19	10	15	60
Czar (S) ..	68	13	15	10	15	60
Painted Lady Giantess (S)	80	14	24	14	11	44
Giant Painted Lady (H) ..	90	14	9	10	15	60
Red Giant (Ca.) ..	84	26	25	15	10	40
Scarlet Emperor (S) ..	90	34	30	24	1	4
White Emperor (S) ..	28	1	6	12	9	36
1 ROW OF EACH.						
Marvel ..	26	2	7	11‡	5	31
Ne Plus Ultra ..	24	7	11†	11	5	31
Prizewinner } (E) ..	27	11	9	11	6	35
A.I. ..	24	9	13	8	4	33
Scarlet Emperor ..	27	11	11	11	6	35
2 ROWS OF EACH.						
Red Giant (Ca.) ..	50	20	20	17‡	8	32
Sutton's Scarlet (Sn.) ..	52	12	15	16	11	41
Emperor's Master (Ca.) ..	50	21	14	20	3	16
Unicum (H) ..	57	14	19	15	10	40
Veitch's Mammoth (Sn.) ..	57	23	23	21	7	25
Painted Lady Giantess (S)	48	20	18	10	11	52
Hollington Scarlet (S) ..	54	21	23†	30	2	6
Elephant (Ca.) ..	52	14	19	24	4	14
Scarlet Emperor (S) ..	49	27	22	9	8	47
Giant Painted Lady (H) ..	56	6	10	18	25	58
White Emperor (S) ..	14	5	4	3	6	66
Mammoth White (Sn.) ..	40	5	6	20	11	35
White Prizewinner (Cl.) ..	39	13	13	8	9	53
Ne Plus Ultra (H) ..	52	29	29	19	5	21
Hackwood Park (S) ..	51	20	25	17	4	19
Czar (S) ..	37	8	12	13	13	50
Abundance (Ca.) ..	33	10	13	9	6	40
Best of All (S) ..	41	25	27	12	1	8
Champion Scarlet (S) ..	49	12	18	14	8	36
Painted Lady Marvel (S)	52	21	24	14	8	36
A.I. (S) ..	53	33	33	15	2	12
Ne Plus Ultra (S) ..	44	20	20	14	7	33
Scarlet Prizewinner (S) ..	27	14	14	21	4	16

† Some plants recovering.

‡ All plants lifted in the 1- and 2-row plots.

*Only 25 plants lifted in the 3-row plots.

The first counts of infected plants were made on June 27th, the diseased plants being recognised by their leaf symptoms.

On July 13th, a second count was made. In some cases the number of diseased plants was smaller than in the first count : this is because in such cases diseased plants apparently recovered and made secondary growth, although the fungus was present in the stems.

On July 31st, the plants were too much grown together for satisfactory counts to be made. The best varieties at that date, in both upper and lower sections of the plot, were Giant Painted Lady, Champion Scarlet and Sutton's Scarlet. All these stood out noticeably on account of their green colour, greater size and vigour, and the small number of infected plants.

On October 5th, 1933, a final count was made of infected plants, 25 plants being taken up and examined, by cutting open the stems of each variety in the 3-row section, and all the plants in the 1 and 2-row sections.

It will be seen from the table that from the point of view of resistance to the disease the following varieties gave the best results, in descending order of resistance: Giant Painted Lady, Czar, Sutton's Scarlet, Painted Lady Giantess and White Prizewinner. Of these Giant Painted Lady was found to be outstanding in growth.

Possible Seed Infection. Sections were made of the peduncles and pedicels to ascertain whether mycelium penetrated into the pods and infected the seeds, but in no case was it found to do so.

Infection Experiments.

1. *By Inoculation of Soil with Cultures.* Sterilised pots of soil were inoculated with one-spore cultures of runner bean wilt *Fusaria* from three localities, N. Q, and W, and seed of Painted Lady Giantess, previously surface-sterilised in mercuric chloride, was sown on December 20th, 1932. The pots were then placed in a warm greenhouse at a temperature of 50°—55°F. On April 11th, 1933, all the plants were taken up with the following results :—

N.	2 plants typically infected,	1 healthy out of 3.
Q.	2 " " "	out of 2.
W.	2 " " "	out of 2.
Control Plot. 3 plants all healthy.		

All four pots were then resown with Sutton's A.1 and returned to the same greenhouse. They were examined on October 3rd, 1933, with the following results :—

N.	4	plants typically infected	out of 4.
Q.	1	" " "	out of 1.
W.	3	" " "	out of 6.
Control Pot.	4	plants all healthy.	

2. *By Inoculation of Soil with Diseased Stems, etc.* Sterilised pots of soil were inoculated as follows :—

1. Infected stems added to soil.
2. Pure culture from source N. added.
3. Control. No treatment.

Seeds of Painted Lady Giantess were sown in the pots on October 17th, 1932, and they were placed in a cool greenhouse.

The plants were examined on April 11th, 1933, with the following results :—

1. 1 plant slightly infected, 2 healthy.
2. 4 plants healthy.
3. 3 " "

All pots were resown with seeds of Sutton's A.1 and returned to the cool greenhouse on the same date.

The resulting plants were examined on August 14th, 1933, with the following results :—

1. All 6 plants infected.
2. 2 plants infected, 1 doubtful, 3 healthy.
3. 6 plants healthy.

The pots were resown on August 24th, 1933, and were examined on October 11th, 1933, with the following results :—

1. 4 plants infected out of 4.
2. 3 " " out of 3.
3. 2 " " and 4 healthy out of 6.

It is assumed that infection of the control pot took place by spattering of soil during watering.

3. *By Use of Infected Soil.* Three pots were filled with soil from infected ground (source N) and sown with surface sterilised seeds of Sutton's A.1. on March 20th, 1933. Two control pots of sterilised soil were similarly sown.

The plants were examined on August 1st, 1933, with the following results :—

Infected Soil.	Pot 1.	5 plants infected, 1 healthy.
	" 2.	3 " " 2 "
	" 3.	3 " " None "
Controls.	Pot 1.	6 plants healthy.
	" 2.	7 " "

4. *By Inoculation of Soil in Outside Plot.* One of the enclosed plots at Long Ashton mentioned in our introductory remarks to this Report was inoculated with a pure culture of the *Fusarium* (source Q) on November 5th, 1932, and the plot was sown with Sutton's A.1. on May 5th, 1933. A control plot alongside was sown on May 19th, 1933.

On June 30th, three plants in the inoculated plot showed typical symptoms. On September 11th twelve plants were lifted and cut open. Of these six were infected and six healthy.

On the control plot the total of 35 plants were lifted on September 11th and found to be all healthy.

It should be noted that in the case of all these experiments the causative *Fusarium* was reisolated from the diseased plants.

Cultural studies of the fungus are in progress.

DISEASES OF BRASSICAE.

Finger-and-Toe (*Plasmodiophora Brassicae*).

1. *Control by Liming, etc.* A trial was laid down in 1932 at Mickleton, Gloucestershire, to demonstrate the value of liming under local conditions for the control of finger-and-toe in Brassicae. The various treatments are beginning to have effect but no striking results are yet available, hence publication of the detailed results will be deferred till next year.

2. *Control by Use of Mercuric Chloride.* A trial was laid down in 1933 to ascertain the effectiveness of the mercuric chloride treatment for finger-and-toe when applied under Evesham conditions.

Two rows, each containing approximately 150 Brussels Sprouts plants, were treated with 1-1600 mercuric chloride on May 11th, 1933. The plants had been put in on the day previous. The solution was applied at the rate of about $\frac{1}{2}$ pint per plant. Row 1, with the exception of the control plants, was treated again on May 31st, with the same strength of solution.

On July 3rd the treated plants appeared stronger and larger than the untreated, and those treated twice were noticeably the best.

This difference continued to be very marked throughout the season. By the middle of September the plants treated twice were approximately twice the height of the untreated, while those treated once were intermediate.

On January 11th, 1934, 100 plants were lifted from each row and counts made of healthy and diseased plants. The results were as follows :—

60 plants	treated twice :	17	clean,	43	infected	(28% clean).
40	„ untreated :	3	„	37	„	(7% „).
60	„ treated once :	4	„	56	„	(7% „).
40	„ untreated :	5	„	35	„	(12.5% „).

It will be seen that two mercuric chloride treatments gave the best results. Many of the treated plants, and especially those treated twice, had only a trace of the disease at the ends of a few roots. These roots too were strong and vigorous, whereas in the untreated plants many of the lower roots had completely decayed, and adventitious roots had formed on the bases of the stems.

DISEASES OF LEEKS.

White Tip.

This disease, caused by *Phytophthora Porri*, is now known from nine localities in the Evesham, Cheltenham and Bristol areas.

In 1931, several plants of outstanding vigour and showing freedom from disease in the midst of a large number of infected plants were selected for seed. Seedlings grown from these plants have been reselected and the progeny is being grown on infected ground in Bristol. These trials are apparently showing useful results, and are to be extended in 1934 to the Cheltenham and Evesham districts.

Basal Rot. In our 1932 Report we recorded a basal rot of leeks, associated with a *Fusarium* sp., which was found to be common in certain fields near Evesham, where this crop is grown every season owing to the peculiar suitability of the soil.

Cultures of this *Fusarium* from two sources, A and B, were used for inoculation experiments. Leek plants grown in pots in a warm greenhouse were used. These were inoculated as follows on January 1st, 1933.

- Pots 1 and 2, Mycelium A in soil.
- „ 3 and 4, Mycelium A inserted in stem.
- „ 5 and 6, Mycelium B in soil.
- „ 7 and 8, Mycelium B inserted in stem.
- „ 9 and 10, Controls.
- „ 11 and 12, Controls, with stem slit.

The plants were placed in a cold greenhouse in March, and outside in April. By April 5th plant No. 3 had collapsed, and considerable pinkish mycelium, bearing spores, was present all over the basal 3 in. of the stems. On that date all the other plants were healthy.

On July 25th, the following plants showed typical disease

symptoms: 1, 3, 4, 5, 7. Of the controls, Nos. 10 and 11 were infected, the spores having probably been carried across from one pot to another by watering or wind.

On September 12th, all the inoculated plants were infected except No. 8. All the diseased plants were rotten at the stem bases, with plentiful *Fusarium* except Nos. 5 and 6. These were quite firm at the stem bases, but there was plentiful *Fusarium* under the old leaves.

Of the control plants, Nos. 9, 10 and 11 were infected.

The experiment indicates that insertion of mycelium into the stem causes much more severe infection than soil inoculation.

The *Fusarium* was re-isolated from these diseased plants.

One of the outside enclosed plots at Long Ashton mentioned in our introductory remarks was inoculated with a culture of the *Fusarium* on April 22nd, 1933. The plot was planted with leeks of the variety Improved Musselburgh on June 18th. On September 12th one of the plants showed typical symptoms.

LETTUCE DISEASES.

Ring Spot ("Rust") (*Marssonina panattoniana*).

Resistance Trials. 1.—A variety trial of winter lettuces for resistance to "rust" was laid down at Frenchay in 1932 on an infected piece of ground. The varieties were arranged in parallel rows. A large circular diseased patch appeared in the centre, and demonstrated the resistance of several varieties.

The results are shown in the accompanying table (Table II).

TABLE II.
RESISTANCE TRIAL OF WINTER LETTUCES TO MARSSONINA AT FRENCHAY.
Counts made April 19th, 1933.

Variety.	Per cent. affected with <i>Marssonina</i> (100 plants counted in each case.)	Comments.
Univalled	100	Badly affected. Poor hearting.
Lee's Immense	94	Badly affected but grows away somewhat.
Arctic King	50	Growth good. Lower leaves close to ground.
Winter Monarch	100	Much checked. Poor.
Excelsior	100	Very many misses. Poor plants.
Schofield's Hardy	100	Badly attacked.
"180"	100	Do.
Winter Victor	100	Do.
MacHattie's Giant	50	Growth rather resembles Arctic King. See above.
Lee's Immense	100	Badly affected but comes away well. Large spreading lettuce.
Blatchford's Giant	100	

2.—A further trial was laid down on a medium sandy soil at Birlingham, near Pershore. The seed was sown on August 17th, and the plants put out on September 28th and 29th. The length of the planting was 170 yards. There were two rows of each variety, except in the case of Lee's Immense, of which there were three rows. The plants were 8 in. apart, and there were about 765 plants of each variety. The rows were 12 in. apart.

The trial was also laid out partly as a manurial trial, but the distribution of the disease was uneven and no significant control following manurial application was visible.

Marssonina was prevalent at one end of the plot on all the varieties by March 22nd.

Counts of plants surviving the winter and of *Marssonina* infected plants were made on four sections of the plot on April 15th and 26th with the results shown in the attached table (Table III).

The first cutting of the crop was made on April 26th, of the variety Imperial. The variety Arctic was almost ready.

The results may be summarised as follows :—

- (a) Plants surviving winter :—Arctic, Standwell, Lee's Immense and MacHattie's Giant are best, in that order.
- (b) Percentage of *Marssonina* infection :—May King, Syston Glory and Standwell show least infection.

TABLE III.

WINTER LETTUCE TRIALS AT BIRLINGHAM, WORCS.—1932–1933.

<i>Variety.</i>	<i>Per cent. of Plants surviving winter (4 counts of 100 each).</i>	<i>Per cent. of Marssonina infection (4 counts of 100 each).</i>
All the Year Round	45	40
All Seasons	55	30
Lee's Immense	68	37
Imperial	53	43
Arctic	73	35
May King	49	25
Syston Glory	45	28
Stanstead Park	53	44
MacHattie's Giant	64	30
Excelsior	59	31
Webb's Wonderful	62	33
Standwell	68	28

Botrytis Disease. We have mentioned in previous reports the prevalence of a winter dying off of lettuces caused by *Botrytis cinerea* in the Bristol district. Table IV gives the result of a small trial of winter lettuces on ground near Frenchay where this trouble is severe. The seeds were sown on August 31st, 1932, and the plants put out in adjoining rows on November 12th—15th.

TABLE IV.

RESISTANCE TRIAL OF WINTER LETTUCES TO BOTRYTIS AT FRENCHAY.
Counts made April 24th, 1933.

Variety.	Numbers surviving out of 100.	Numbers Fit to Cut.
Arctic	85	3
Imperial	95	56
Lee's Immense	85	11
Marvel	66	—
Queen of the May	51	—
Spring Beauty	96	42
Standwell	69	2
Supreme	46	—

Mosaic Disease (?).

It was suggested in our 1930 report and in another publication (7) that much of the non-hearting of lettuces prevalent in the area may be due to a mosaic disease.

Seeds were kept from a "mosaic" cos lettuce plant in 1932. These were sown at Long Ashton in 1933 and of 500 plants 119 seedlings (*i.e.* 22 per cent.) were clearly infected with mosaic.

MINT DISEASES.

Mint Rust (*Puccinia Menthae*).

General Observations. During 1933 an examination was made of the black wilted shoots so often found in mint beds affected with rust (*Puccinia Menthae*). In every case such shoots were found to be badly affected with rust lower down the stem, and since no other organism could be held responsible, it is considered that this wilting follows heavy rust infection.

Treatments. In 1932-33 further tests were carried out of treatments which appeared to be valuable in the previous season. The results are summarised in the following tables:—

TABLE V.
MINT RUST CONTROL TRIALS.

1. *Glasshouse Trials at Cheltenham.*

No. of Bed.	Treatment.	No. of Rusted Shoots in Beds of Equal Size.			
		Mar. 16.	Apr. 3.	Apr. 18.	Total.
1	Tops cut early (September)	13	75	37	125
2	Plants sprayed with 7½% Tar Oil mid-December ..				
		9	60	20	89
3	Tops cut early (September)	12	150	68	230
4	Plants not sprayed ..				
		11	124	32	167
5	Tops cut when lifting (Jan.)	38	230	38	306
6	Plants not sprayed ..				
		22	180	83	285

TABLE V.—(Continued.)

2. *Glasshouse Trials at Long Ashton.*

No. of Bed.	Treatment.	No. of Rusted Shoots, (3 counts.)	Amount Picked, Doz. bunches.
<i>A. Mentha villosa-nervata</i> (dark type).			
1.	Tops cut late (December). Plants watered with 6% Tar Oil, December 16th.	114	38
2.	Tops cut late (December). Roots washed ..	200	25
3.	Tops cut late (December). Plants untreated	100	34
<i>B. Mentha villosa-nervata</i> (pale type).			
1.	Tops cut early (August). Plants watered with 6% Tar Oil (January)	3	13
2.	Tops cut late (December). Plants watered with 6% Tar Oil (January)	8	20
3.	Tops cut late (December). Plants untreated	37	16
4.	Tops cut early (August). Plants untreated	33	15

3. *Outside Plot at Long Ashton.*

Plants heavily infected with rust were cut to the ground on December 16th, 1932, and a strip was watered with a copper sulphate solution (1 lb. to 2 gallons water). A similar strip was untreated.

Counts of rusted shoots were made on May 5th, 1933, with the following results :—

Treated : 38 rusted shoots. Untreated : 120 rusted shoots.

The treated strip was also almost free from weeds, the untreated being very weedy, while the mint shoots were stronger and more numerous in the former case.

It will be seen that, in common with previous years' results, tar-oil spraying in late autumn or early winter tended to give a considerable control of the disease. The use of copper sulphate solutions will be experimented with further.

Germination of Spores. Mint leaves bearing teleutospores of *Puccinia Menthae* were placed in sterile test tubes with damp cotton wool. The latter were then placed on November 21st, 1933, in three different temperatures (Av. 33°F., 52°F. and 60°F.). Spore samples were examined frequently. Germination of the spores was taking place at all the temperatures on November 29th and December 19th, 1933.

Susceptibility of Species of Mentha. A collection of species and varieties of mint is being assembled at Long Ashton to determine the susceptibility of these to the rust. The uredospore and teleutospore stages were severe in the Station plantings in 1933, and the following list indicates the occurrence of the fungus on November 11th on the species under cultivation.

- A. *Rust present.* *M. cordifolia.* Plentiful, causing some leaf fall.
M. niliaca nemorosa. Not plentiful.
M. rotundifolia variegata. Slight, and practically no leaf fall.
M. spicata. Fairly plentiful. Some leaf fall.
M. villosa-nervata. Severe on both dark green and pale types. Much leaf fall.
- B. *Rust absent.* *M. citrata.*
M. piperita saxonis.

ONION DISEASES.

White Rot.

We are at present experimenting in the Evesham area on the possible control of white rot on winter onions by means of the application of formalin to the seed drill, as is done in the control of onion smut.

Onion Smut.

A case of onion smut, caused by the fungus *Urocystis Cepulae*, was found at Offenham on August 30th, 1933. This is apparently the first record of this disease, which is scheduled by the Ministry, in this Province.

PARSNIP DISEASES.

"Canker."

As indicated in last year's Report a species of *Ascochyta* has been found to be the cause of a type of parsnip canker prevalent near Bristol (Plate II, Fig. 1). One of the enclosed plots at Long Ashton was inoculated with a pure culture of the fungus, and parsnips of the variety The Student, grown previously in sterile soil, were set out in it on May 6th, 1933. On November 10th, 18 parsnip roots which were lifted showed no disease. Nine more were lifted on December 12th; two of these showed slight infection by *Ascochyta*. The remaining roots were lifted on January 12th, 1934; of these five were infected, and eleven clean. Most of the roots also showed infestation by dipterous larvae (? carrot fly). From a control plot alongside nine parsnips were lifted: all nine were free from *Ascochyta* canker, but there was slight fly damage.

PEA DISEASES.

Foot Rot.

The importance and prevalence of foot rots of peas were again noticeable in 1933. The problem of pea "sickness" (*Heterodera* + *Fusarium*) is discussed in a separate article in this Report by Walton and ourselves. Further work on the *Fusarium* side of the problem has been carried out this year. The prevalence of the *Martii* group on the roots of peas has again been emphasised, and further satisfactory inoculation experiments have been carried out with this group.

Two of the enclosed vegetable disease plots were inoculated with cultures of the *Martii* group from different sources, and seeds of the variety Early Bird were sown on the plots on April 12th, 1933. Seeds of Green Admiral, Yellow Admiral, Horal and Rice's 330 (varieties sent us by Dr. Stone, of Ontario Agricultural College, and stated to be somewhat resistant to Canadian root rots), were also sown on May 5th, 1933. Control plots of Early Bird were sown on May 19th.

The plots were examined on August 5th. Practically all the peas on the inoculated plots were badly infected with foot rot, while the control plots were entirely clean. All four Canadian varieties were infected.

Pea Seed Disinfection.

Our work on pea seed disinfection, referred to in our 1932 Report, was continued. A quantity of pea seed was received from seed merchants as useless for trade, being much spotted. The spotting was as usual mostly due to infection by *Mycosphaerella pinodes* and *Ascochyta Pisi*.

Laboratory Tests. 1.—100 of these seeds were placed on damp filter paper and removed as soon as mycelium appeared. This treatment gives an approximate estimate of the percentage of infected seeds.

In ten days 91 seeds were removed. The remainder germinated.

2.—50 seeds were shaken up with 1 gm. each of the following substances, then spaced out in Petri dishes, one dish for each treatment. Seeds showing fungus growth were removed as quickly as possible. The duration of the experiment was 15 days.

TABLE VI.

PEA SEED DISINFECTION.

Treatment.				Sticking. Powers of material.	Seeds showing fungus growth.	Germinated.	No germination, but free from fungus growth.
1.	Agrosan	..	..	Poor	37	10	3
2.	Ceresan	..	..	Good	34	13	3
3.	"	..	..	"	19	15	16
4.	Lunasan	..	..	"	32	9	9
5.	Abavit B	..	..	Fair	36	11	3
6.	Granosan	..	..	Good	23	8	19
7.	413a (Meyer)	..	..	"	3	—	47
8.	Copper sulphate (anhydrous)	..	..	Bad	49	1	—
9.	Copper monohydrate	..	..	Very poor	46	4	—
10.	Cuprous oxide	..	..	Fair	42	6	2
11.	Copper tartrate	..	..	Bad	41	9	—
12.	Red lead	..	..	"	44	6	—
13.	Control	..	..	..	36	13	1
14.	"	..	..	..	36	14	—
15.	"	..	..	..	34	14	2
16.	"	..	..	..	35	14	1

It will be seen that fewest infected seeds were removed from Treatments Nos. 3 and 6 (excepting No. 7, which prevented germination), and that none of the other treatments increased the germination under laboratory conditions.

3. Six lbs. of the same seeds were treated, 1 lb. with each of 6 fungicides, and sown outside alternately with 6 lb. of untreated seeds on April 24th, 1933. The results are shown in the accompanying table:—

TABLE VII.
PEA SEED DISINFECTION.

<i>Treatment.</i>	<i>Germination (after 18 days). No. of plants.</i>	<i>Crop Weights (July 5th, 1933). in lbs.</i>
(a) Control	417	11 $\frac{1}{2}$
(b) Agrosan	432	12 $\frac{3}{4}$
(c) Control	420	8 $\frac{3}{4}$
(d) Ceresan	495	10 $\frac{3}{4}$
(e) Control	410	8 $\frac{3}{4}$
(f) Lunasan	530	9 $\frac{1}{4}$
(g) Control	328	3 $\frac{3}{4}$
(h) Cuprous oxide	371	5 $\frac{3}{4}$
(i) Control	254	4 $\frac{3}{4}$
(j) Granosan	393	8 $\frac{1}{4}$
(k) Control	323	7 $\frac{1}{2}$
(l) Abavit B	335	7 $\frac{1}{4}$

It will be seen from Table VII that a slight increase in germination usually follows the treatment of pea seed by organic mercury disinfectants when such seed is sown in the ground.

Seed Treatments on a Field Scale. Nine lots of seed were treated with organic mercury disinfectants for growers, 113 $\frac{1}{2}$ lbs. being treated in all. These lots were sown alongside untreated seed, germination counts made, and crop weights taken. It should be noted that none of the samples were markedly diseased. The results are given in Table VIII.

TABLE VIII.

PEA SEED TREATMENTS: FIELD TRIALS, 1933.

No.	Locality.	Weight of seed treated.	Variety.	Treatment.	Crop weights (in lbs.) Treated. Untreated.	Crop increase from treatment.	Crop increase per 7 lbs. of seed treated.
1.	Offenham	14	Laxton's Superb	Ceresan ..	134	17	8½
2.	"	14	"	Agrosan ..	*120	3	1½
3.	Offenham	14	Early Bird	Ceresan ..	515	13	6½
4.	Badsey	7	British Lion	Ceresan ..	147	26	26
5.	Hinton	28	Laxton's Superb	Ceresan ..	—	18	4½
6.	Offenham	8½	Early Bird	Ceresan ..	*No difference.	—	—
7.	Bretforton	7	Lord Chancellor	Ceresan ..	280	20	20
8.	"	14	British Lion	Ceresan ..	—	54	27
9.	"	7	Senator	Agrosan ..	No difference.	—	—

* Treated plants said to have kept green longer than controls.

NOTE: In every case an equal quantity of untreated seed was sown immediately adjoining the treated.

In those cases where the crop weights of both treated and untreated seeds were obtained, seed treated with Ceresan gave a crop of 1,076 lbs., as against a crop of 1,000 lbs. from the untreated, or an increase in crop of 7.6 per cent. Taking all the results with Ceresan, there was an increase in crop of about 13 lbs. per 7 lbs. of seed treated.

VEGETABLE MARROW DISEASES.

Mosaic. Work on marrow mosaic was continued, but many features of the disease still remain obscure. The field mentioned in our last Report was again planted up with marrows, and although mosaic plants of *Bryonia dioica* had been removed from the neighbouring hedgerows there was still marked infection with the disease, and roguing of diseased plants was insufficient to keep it under control. It was noted in several cases that removal of a diseased branch soon after the first appearance of symptoms resulted in the rest of the plant remaining healthy till the end of the season.

No positive results have been obtained in our endeavours to transmit the disease from *Bryonia* or ascertain the common vector of the disease.

Acknowledgment.

Thanks are due to the "Worcestershire County Council Agricultural Chronicle" for the loan of blocks in Plate I.

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"Vegetable Diseases in Worcestershire"—

- I. "Halo Blight of Dwarf Beans," Vol. 1, No. 2, Feb., 1933.
- II. "White Tip Disease of Leeks," Vol. 1, No. 3, May, 1933.
- III. "Leaf and Pod Spots and Foot Rots of Peas," Vol. 1, No. 4, Aug., 1933.

PLATE I.

Asparagus Diseases.

- FIG. 1. Asparagus Rust (*Puccinia Asparagi*).
- FIG. 2. Violet Root Rot of Asparagus (*Rhizoctonia Crocorum*).

PLATE II.

- FIG. 1. Parsnip Canker caused by *Ascochyta* sp.
- FIG. 2. Wilt of Runner Bean caused by *Fusarium* sp.

CIDER MAKING TRIALS FOR THE SEASON 1932-33.

By B. T. P. BARKER, V. L. S. CHARLEY and P. T. H. PICKFORD.

The 1932 cider apple crop was again below average on the whole, and in most districts showed no improvement on the 1931 crop. With the exception of some parts of Monmouthshire the crop was poor in each county.

The average specific gravity of all the apples examined at Long Ashton was 1.0492. This was a little higher than in 1932.

The quality of the cider was very fair. It was pleasant and considerably fuller in flavour than that of the previous year. An outstanding feature was the marked astringency of the "sweet" and "bittersweet" ciders.

The Cider and Perry Competitions.

For the eighth year in succession competitions on similar lines to those described in earlier reports were arranged.

119 entries of fruit were received. Of these 113 were apples and 6 were pears. The fruit was stored until fit for milling, and the subsequent treatment given to each cider or perry was the same except for the following differences as to the filtration period.

In Classes I, II and VI, the ciders and perries were filtered when the specific gravity of the juice was 1.030 ; in the Classes III and IV the filtration gravity was 1.025.

The Competitions were open to growers residing in the counties of Devon, Dorset, Gloucestershire, Herefordshire, Monmouthshire, Somersetshire and Worcestershire. The entries from the different counties were distributed as follows:—Devon, 18 ; Dorset, 3 ; Gloucestershire, 6 ; Herefordshire, 18 ; Monmouthshire, 51 ; Somerset, 18 ; Worcestershire, 5.

The ciders were judged on April 26th, 1933, by Major E. W. Farwell, Kilmersdon, Bath ; Messrs. W. R. Bufton, Widemarsh, Hereford ; D. Phillips Morgan, Bushley, Worcs. ; and the perries on the same date by Mr. J. H. Wootton, Byford, Hereford.

Class I (Kingston Black), with 8 entries, was a good class as a whole. The acidity was unusually high for Kingston Black in several of the samples, but they were pleasant in flavour, having more character than in the previous year. No. 2, which was awarded the 1st prize, was a less brisk cider of very full flavour. No. 4, the 2nd prize, was fruity, soft and of high quality.

Class II (Sharp Varieties) was divided as in the three previous years, into two groups :—A, with an acidity of 0.80% or above ; B, with an acidity below 0.80%. Group A comprised ciders which, owing to their high acid content, are only suitable for blending with ciders of low acidity, whereas the ciders in Group B need no blending in that respect.

The ciders in Group A (13 entries) were good in each instance, being fuller in flavour than the average sharp variety. No. 15, a Frederick cider gaining the 1st prize, had a rather different and distinct flavour from all the other examples of that variety in the group. No. 20, Rockfield Cowarne, awarded 2nd prize, had a very keen penetrating acid character and was very clean and fresh on the palate. No. 19 was a typical rich Frederick from the Dingestow district.

Group B (25 entries) was a good class and on the average higher in quality than last year, being marked by the particularly good aroma throughout. No. 26, Jackson's White, which was awarded the 1st prize, was a very soft, mild, medium sharp with a fine aroma. The 2nd prize; Sample No. 35, Langworthy, had a very strong fruity flavour. No. 24, Styre, had not so much character but was very pleasant in flavour with a good aroma. It was a cider suitable as a drink alone. No. 38, Crimson King, was fairly good with a pleasant, agreeable, acid flavour. Red Sharp, No. 39, a new variety in the Competitions, was a Monmouth apple resembling a mild Frederick. This was a good cider but rather too sharp for the class. No. 23, Red Sharp ; No. 30, Strawberry Red ; No. 42, Pyleigh, and No. 44, Newbold's Sharp, were decidedly poor and coarse ciders, and these varieties are not considered worthy of further trial.

Class III (Sweet Varieties) attracted 30 entries. They proved an outstandingly good, even lot, of unusually high character for "sweet" ciders. No. 53, Sweet Alford, was a particularly good cider, with a fine fruity flavour and aroma, and undoubtedly deserved the premier award given to it. No. 55, Berkeley Pippin, which was awarded the 2nd prize, was also an excellent cider, having a very outstanding apple flavour. The Sweet Alford, No. 57, was perhaps the most characteristic of this variety, being a

most pleasant cider. No. 60, Woodbine, was a very clean pleasing typical "sweet." Willow Apple, No. 52, was a new variety in the Competition. This proved to be a very interesting new variety, which stood quite alone in character. It had a good flavour with an agreeable first taste, but the aftertaste was rather disappointing.

Class IV (Bittersweet Varieties), with 17 entries, was again a very even class. Most of the ciders were clean on the palate, but the aroma was not so good as in some of the other classes. The acid character was remarkably prominent for a Bittersweet Class, while the tannin flavour was very marked also. The 1st and 2nd prizes were awarded to Cherry Normans, No. 78 and No. 79. No. 78, the 1st prize exhibit, was a fine bittersweet with a full very flavour and a good aroma. No. 79 was also a fine bittersweet. Strawberry Norman, No. 88, was exceptionally good for this variety, while No. 77, Tremlett's Bitter, was a very good, pleasant cider in which the tannin flavour was very pronounced. No. 86, Strawberry Norman, was rather coarser in flavour. Yellow Norman, No. 87, an interesting new variety in the Competitions, was a very rich cider; although the tannin stood out far too prominently in it unblended, the sample was a useful blender in small proportions. White Norman, No. 93, was a good cider but not a typical bittersweet; it lacked a definite tannin character. The four entries of the variety French were of very similar character. They were all rather poor, coarse ciders.

Class V for Blends (20 entries) was treated on the same lines as last year. The exhibitors themselves were invited to select the proportions for one blend (A), the Institute determining the proportions for a second blend (B). As before, each entry was a blend made up from the ciders of an individual exhibitor entered in the Sharp Class and either or both of the Sweet and Bittersweet Classes. On the whole this class did not produce such outstandingly good ciders as were found in the Kingston Black, Sweet and Bittersweet Classes. They were all sound, but the acid and tannin flavours were too prominent, a feature characteristic of this season's vintage. Considering the high quality of the single varieties from which they were made, it was disappointing that the blends did not produce better balanced ciders.

The competitors' suggestions for the proportions of the single varieties in their blends proved more satisfactory than those of any previous year and in many cases it was impossible for the Institute to improve upon them.

No. 107A, which was awarded the 1st prize, was a good cider, but had rather too much of the typical Frederick acid character

predominating. No. 107B was rather similar with a rather less prominent acidity. The 2nd prize, Sample No. 108A, was a very good cider, and both this and No. 108B were very attractive. Nos. 109A and B were excellent ciders, but rather too high in astringency.

Class VI for Perry (6 entries) was again a disappointing one, although the quality was quite fair considering this was a very poor season for perry. The 1st award, No. 118, Green Pear, was a very clean drink and, although not outstanding in any way, was the best. The Blakeney Reds were considered rather above average for that variety. No. 119, Oldfield, was very unpleasant and far from being up to the standard of this variety.

Non-Competitive Ciders.

Ciders and Perry made from Single Varieties sent for trial and from the Trial Orchards. Brown Snout, No. 121, from one of the Worcestershire Trial Orchards, proved a very useful bittersweet.

The variety, No. 122, tested under the name of Médaille d'Or, yielded an excellent bittersweet cider of milder and more pleasing character than is usual with the true Médaille d'Or, with a fine colour and perfect aftertaste. The fruit of this variety is almost a typical Médaille d'Or in appearance, but the habit of the tree is distinct, being more vigorous and not subject to the splitting of branches at the forks so characteristic of the true variety. No. 123, "Late Cider Variety," was a very good cider of the "sweet" class.

From the Long Ashton Trial Orchard, Dabinett, No. 125, was of fair quality, although it had rather a distinct crude tannin flavour. Knotted Kernel, No. 126, produced an excellent cider. Lambrook Pippin, No. 127, was not quite up to its usual high standard. No. 128 was a cider made from an admixture of several bittersweets in the Long Ashton Trial Orchards and was a very good quality blending cider.

Blakeney Red, No. 120, was a good, full-flavoured perry, medium brisk and very characteristic of this variety.

Jersey Varieties. Two varieties of apples were sent for trial from Jersey, France (No. 124) and Douce Dame. The variety France made a cider of fair quality belonging to the "sweet" class and suitable for blending. Unfortunately the quality of Douce Dame could not be fairly judged owing to the development of cider sickness in the samples.

Report of Judges on the Long Ashton Cider Competitions, 1932-1933.

The judging of the ciders in these competitions took place on April 26th, 1933.

A few general comments on the ciders may be made before dealing with the individual classes. The average specific gravity of the freshly expressed juices was only slightly higher than last year, but the quality of the ciders in general showed a considerable improvement on those of the previous season.

The acidity was generally slightly higher than usual in the Kingston Black and the Sharp Classes and, owing to the high percentage of tannin, the astringent flavour was very marked in the Sweet and Bittersweet Classes. For this reason the higher limit of 0.2% of tannin in the Sweet Class was raised to 0.25%. This change was effected in order to retain in the Sweet Class those ciders which are normally considered to belong to this class.

In general the flavour of the ciders was pleasant and fuller than in last year's competitions.

There was a noteworthy absence of taints in all cases.

Class I, for Kingston Black apples, consisted of 8 entries. These were all good even ciders with the average quality considerably above that of last year in spite of the high acidity.

Class II A, for high acid ciders, was composed of 13 entries, 10 of which were Fredericks. For this type of cider the majority of the entries were of average quality, but several were distinguished by a fuller flavour than is usual in very sharp ciders.

Class II B, for medium sharp varieties, comprised 25 entries. Again the average quality was higher than that of last year's class, an outstanding feature being the very attractive aroma in nearly all the entries.

Class III, for sweet varieties, with 30 entries, was remarkable for the even character of the ciders. Here again, the samples as a whole were far above those of the previous year in quality.

Class IV, for bittersweet varieties, was notable for the prominence of the acid and tannin characters. Although the class as a whole was remarkably level the aroma was not so attractive as in the previous classes. The ciders gaining the first three awards were excellent bittersweets. There were 17 entries.

The Blend Class (Class V) was again treated on the lines adopted in last year's competition. The blends were somewhat disappointing in view of the high quality of many of the single variety ciders from which they were prepared. It was generally found that the acid and tannin characters of the ciders did not blend satisfactorily, differing in this respect from the previous two seasons' blends.

It is interesting to note that in nearly all the cases the competitors had chosen the best proportions of their single varieties for their blends, leaving little room for improvement by the Institute's blend.

The Class for Perries (Class VI) was small, only 6 entries being made. The quality was quite as good as could be expected for the season. No perry of outstanding merit was noted, but the three entries of Blakeney Red pears afforded perries distinctly above the average for that variety.

In conclusion, we express our appreciation of the complete absence of taints and absolute impartiality in method of display of exhibits, which reflects great credit on those responsible for work done by the Institute. It made the Competitions competitive in the fullest and fairest sense.

(Signed) WILLIAM R. BUTTON.

E. W. FARWELL.

D. PHILLIPS MORGAN.

JOHN H. WOOTTON.

Judges.

TABLE I.
CIDERS.
COMPETITION VARIETIES.

No.	Name of Variety.	Date of making.	Specific Gravity of Fresh Juice.	Malic Acid per cent.	Tannin per cent.	Rate of fermentation.	Date of Filtering.	Specific Gravity at time of Filtering.	Specific Gravity May, 1933.	Name and Address of Grower.
CLASS 1.—KINGSTON BLACKS—										
1	Kingston Black ..	23/11/32	1.062	0.79	0.22	5.0	7/2/33	1.030	1.028	Major C. Jackson, Charlton Mackrell, Som.
2	" "	23/11/32	1.060	0.72	0.22	4.4	3/2/33	1.030	1.029	L. E. Guilling, Bushley, Worcs.
3	" "	23/11/32	1.062	0.75	0.22	4.3	1/3/33	1.030	1.028	W. Hill, Kittisford, Som.
4	" "	23/11/32	1.056	0.69	0.24	3.1	13/2/33	1.030	1.029	J. E. Edwards, Norton Canon, Her.
5	" "	23/11/32	1.063	0.79	0.18	4.1	1/3/33	1.030	1.029	P. E. Bomford, Upton Snodsbury, Worcs.
6	" "	23/11/32	1.063	0.76	0.24	5.0	15/2/33	1.030	1.030	W. R. Thomas, Nunnington, Her.
7	" "	23/11/32	1.057	0.70	0.20	4.1	30/1/33	1.030	1.030	J. Stead, Penhow, Mon.
8	" "	23/11/32	1.064	0.83	0.22	5.3	3/2/33	1.030	1.029	H. E. Dabinett, Somerton, Som.
CLASS 2A.—SHARP VARIETIES. Acidity 0.8 per cent. or above—										
9	Redstreak ..	24/10/32	1.039	1.23	0.12	8.0	3/11/32	1.030	1.026	G. Breakwell, Perthyre, Mon.
10	Frederick ..	26/10/32	1.045	1.00	0.10	4.7	10/11/32	1.030	1.029	B. Williams, Llanfellowell, Mon.
11	" "	26/10/32	1.050	1.10	0.14	6.3	8/11/32	1.030	1.028	J. E. Bradley, Rockfield, Mon.
12	" "	26/10/32	1.048	1.20	0.10	5.0	17/11/32	1.030	1.027	G. Breakwell, Perthyre, Mon.
13	" "	26/10/32	1.048	1.23	0.11	5.6	21/11/32	1.030	1.028	D. A. & R. R. Watkins, Rockfield, Mon.
14	" "	26/10/32	1.047	1.14	0.11	5.7	17/11/32	1.030	1.027	Captain Beer, Llanvair, Mon.
15	" "	26/10/32	1.048	1.15	0.10	6.0	12/11/32	1.030	1.027	F. F. Scudamore, Nantyderi, Mon.
16	" "	26/10/32	1.047	1.16	0.11	4.0	21/11/32	1.030	1.030	E. M. Cowles, Hendre, Mon.
17	" "	26/10/32	1.047	1.11	0.12	4.7	19/11/32	1.030	1.027	R. P. Jones, Monmouth, Mon.
18	" "	26/10/32	1.046	1.28	0.13	6.0	7/11/32	1.030	1.026	L. P. Williams, Raglan, Mon.
19	" "	9/11/32	1.050	1.14	0.09	5.0	14/12/32	1.030	1.029	S. J. Mullins, Dingestow, Mon.
20	Rockfield Cowarne ..	11/11/32	1.050	0.94	0.14	6.6	2/12/32	1.030	1.028	J. E. Bradley, Rockfield, Mon.
21	Yellow Sharp ..	15/11/32	1.046	0.98	0.07	8.0	28/11/32	1.030	1.027	J. F. Bomford, Peopleton, Worcs.

TABLE I.—*continued.*

COMPETITION VARIETIES.										
No.	Name of Variety.	Date of making.	Specific Gravity of Fresh Juice.	Malic Acid per cent.	Tannin per cent.	Rate of fermentation.	Date of Filtering.	Specific Gravity at time of Filtering.	Specific Gravity May, 1933.	Name and Address of Grower.
CLASS 2B.—MEDIUM SHARP VARIETIES. Acidity below 0.8 per cent.—										
22	Breakwell's Seedling	18/10/32	1.036	0.48	0.20	5.0	31/10/32	1.030	1.028	G. Breakwell, Perthyre, Mon.
23	Red Sharp	8/11/32	1.057	0.64	0.12	16.5	17/11/32	1.030	1.025	L. P. Williams, Raglan, Mon.
24	Styre	8/11/32	1.044	0.58	0.08	6.0	26/11/32	1.030	1.029	D. A. & R. R. Watkins, Rockfield, Mon.
25	Stoke Red	8/11/32	1.046	0.69	0.23	4.6	3/12/32	1.030	1.030	H. H. Sealy, Rodney Stoke, Som.
26	Jackson's White	8/11/32	1.047	0.52	0.16	7.0	23/11/32	1.030	1.025	Major Jackson, Charlton Mackrell, Som.
27	Normington	11/11/32	1.045	0.77	0.13	9.6	22/11/32	1.030	1.028	E. T. Lewis, Dymock, Glos.
28	Broom Apple	11/11/32	1.050	0.64	0.21	8.6	22/11/32	1.030	1.027	C. & R. D. Lewis, Raglan, Mon.
29	Kempley Red	11/11/32	1.048	0.71	0.15	6.6	2/12/32	1.030	1.028	W. Wootton, Byford, Her.
30	Strawberry Red	15/11/32	1.043	0.67	0.11	8.5	28/11/32	1.030	1.026	D. A. & R. R. Watkins, Rockfield, Mon.
31	Sour Natural (Langworthy)	15/11/32	1.049	0.62	0.12	7.5	12/12/32	1.030	1.029	J. Halse & Sons, Newton St. Cyres, Devon.
32	White Sheep's Nose	15/11/32	1.046	0.54	0.22	6.2	3/12/32	1.030	1.030	Mrs. Clarke, Honiton, Devon.
33	Langworthy	18/11/32	1.043	0.56	0.11	4.6	10/12/32	1.030	1.028	E. T. Bryant, Taunton, Som.
34	Wyatt's Seedling (Langworthy)	18/11/32	1.045	0.60	0.12	3.8	17/12/32	1.030	1.028	W. J. Berry, Newton St. Cyres, Devon.
35	Sour Natural (Langworthy)	18/11/32	1.048	0.65	0.14	4.4	19/12/32	1.030	1.029	A. Pope, Crediton, Devon.
36	Normans	18/11/32	1.053	0.56	0.17	8.6	5/12/32	1.030	1.026	G. Williams & Son, Westhide, Her.
37	White Sharp	28/11/32	1.053	0.78	0.16	7.7	19/12/32	1.030	1.028	G. Breakwell, Perthyre, Mon.
38	Crimson King	28/11/32	1.054	0.56	0.14	4.8	28/12/32	1.030	1.027	W. Hill, Kittisford, Som.
39	Red Sharp	28/11/32	1.046	0.77	0.10	3.1	4/1/33	1.030	1.029	E. M. Cowles, Hendre, Mon.
40	Colmans	28/11/32	1.043	0.54	0.12	4.2	20/12/32	1.030	1.030	H. Walters, Newton St. Cyres, Devon.
41	Hunt's White Sharp	2/12/32	1.047	0.54	0.18	6.5	22/12/32	1.030	1.028	W. Hunt, Easton-in-Gordano, Som.

TABLE I.—*continued.*

COMPETITION VARIETIES.										
CLASS 2B.—MEDIUM SHARP		VARIETIES.		Acidity below 0.8 per cent.— <i>contd.</i>						
42	Pyleigh ..	2/12/32	1.048	0.53	0.17	8.2	16/12/32	1.030	1.026	H. C. Hancock, Milverton, Som.
43	Golden Ball ..	5/12/32	1.043	0.60	0.19	5.5	23/12/32	1.030	1.030	J. Bowditch, Stoke Abbott, Dorset.
44	Newbold's Sharp ..	5/12/32	1.046	0.62	0.12	7.5	21/12/32	1.030	1.024	J. E. Bradley, Rockfield, Mon.
45	Sour Clusters ..	9/12/32	1.042	0.60	0.22	5.0	27/12/32	1.030	1.029	Mrs. Clarke, Honiton, Devon.
46	Heavy Bearer ..	18/11/32	1.049	0.66	0.12	7.3	17/12/32	1.030	1.024	J. F. Bomford, Peopleton, Wores.
CLASS 3.—SWEET VARIETIES—										
47	Sweet Normans ..	21/10/32	1.037	0.21	0.17	3.7	8/11/32	1.025	1.022	J. E. Bradley, Rockfield, Mon.
48	Early Sweet ..	26/10/32	1.042	0.32	0.15	7.0	7/11/32	1.025	1.020	G. Breakwell, Perthyre, Mon.
49	Rockfield Cummy ..	1/11/32	1.037	0.20	0.13	2.2	29/11/32	1.025	1.023	"
50	Pound Apple ..	7/11/32	1.047	0.34	0.15	7.5	18/11/32	1.025	1.016	Mrs. Clarke, Honiton, Devon.
51	Sweet Alford ..	7/11/32	1.049	0.26	0.15	9.5	21/11/32	1.025	1.021	J. Peek, Ottery St. Mary, Devon.
52	Willow Apple ..	7/11/32	1.048	0.25	0.18	7.3	15/12/32	1.025	1.023	W. G. Bradley, Tregare, Mon.
53	Sweet Alford ..	15/11/32	1.049	0.20	0.12	4.2	26/1/33	1.025	1.025	W. J. Berry, Newton St. Cyres, Devon.
54	Sweet Alford ..	15/11/32	1.049	0.25	0.13	4.4	26/1/33	1.025	1.024	A. Pope, Crediton, Devon.
55	Berkeley Pippin..	28/11/32	1.051	0.27	0.15	8.7	21/12/32	1.025	1.023	W. Hunt, Easton-in-Gordano, Som.
56	Sweet Alford ..	28/11/32	1.049	0.19	0.13	6.2	6/1/33	1.025	1.023	F. Vincent, Pinhoe, Devon.
57	Sweet Alford ..	28/11/32	1.050	0.21	0.16	5.6	14/1/33	1.025	1.023	S. Cursons, Dunsford, Devon.
58	Best Bearer ..	28/11/32	1.056	0.34	0.15	6.7	31/12/32	1.025	1.024	J. Bowditch, Stoke Abbott, Dorset.
59	Sweet Woodbine ..	28/11/32	1.048	0.39	0.12	5.4	2/1/33	1.025	1.022	H. Walters, Newton St. Cyres, Devon.
60	Woodbine ..	5/12/32	1.057	0.28	0.18	7.0	12/1/33	1.025	1.024	E. T. Bryant, Taunton, Som.
61	Perthyre ..	11/11/32	1.054	0.34	0.17	7.3	15/12/32	1.025	1.022	W. G. Bradley, Tregare, Mon.
62	Perthyre ..	11/11/32	1.052	0.32	0.20	8.0	2/12/32	1.025	1.021	S. J. Mullins, Dingestow, Mon.
63	Perthyre ..	11/11/32	1.047	0.32	0.20	7.3	15/12/32	1.025	1.022	A. L. Thomas, Manson, Mon.
64	Perthyre ..	15/11/32	1.049	0.25	0.20	6.5	15/12/32	1.025	1.022	J. E. Bradley, Rockfield, Mon.
65	Perthyre ..	11/11/32	1.052	0.31	0.21	9.3	28/11/32	1.025	1.015	D. A. & R. R. Watkins, Rockfield, Mon.
66	Belle Norman (Perthyre) ..	11/11/32	1.051	0.34	0.21	8.7	2/12/32	1.025	1.020	R. P. Jones, Monmouth, Mon.
67	Perthyre ..	15/11/32	1.052	0.27	0.21	7.0	13/12/32	1.025	1.021	A. T. Blake & Sons, Monmouth, Mon.

TABLE I.—*continued.*

CIDERS.

COMPETITION VARIETIES.

No.	Name of Variety.	Date of making.	Specific Gravity of Fresh Juice.	Malic Acid per cent.	Tannin per cent.	Rate of fermentation.	Date of Filtering.	Specific Gravity at time of May, 1933.	Name and Address of Grower.
CLASS 3.—SWEET VARIETIES.— <i>contd.</i>									
68	Perthyre ..	15/11/32	1.051	0.38	0.21	8.0	10/12/32	1.025	G. Breakwell, Perthyre, Mon.
69	Perthyre ..	11/11/32	1.048	0.32	0.22	5.6	19/12/32	1.025	Captain Beer, Llanvair, Mon.
70	Perthyre ..	11/11/32	1.051	0.28	0.24	7.0	23/12/32	1.025	E. M. Cowles, Hendre, Mon.
71	Woodbine ..	5/12/32	1.060	0.31	0.25	8.2	12/1/33	1.025	W. Hill, Kittisford, Som.
72	Belle Norman (Perthyre) ..	28/11/32	1.056	0.25	0.22	9.2	22/12/32	1.025	J. Bourne, Burghill, Her.
73	Clusters ..	5/12/32	1.057	0.28	0.21	7.5	4/1/33	1.025	W. Hill, Kittisford, Som.
74	Cummy Norman ..	28/11/32	1.056	0.32	0.21	4.8	5/1/33	1.025	W. R. Thomas, Nunnington, Her.
75	Rockfield Cummy ..	24/10/32	1.042	0.22	0.25	4.4	17/11/32	1.025	D. A. & R. R. Watkins, Rockfield, Mon.
76	Red Norman ..	24/10/32	1.040	0.42	0.22	3.4	2/12/32	1.025	S. W. Jones, Tregare, Mon.
CLASS 4.—BITTERSWEET VARIETIES.									
77	Tremlett's Bitter ..	8/11/32	1.052	0.30	0.36	5.2	23/11/32	1.025	F. Vincent, Pinhoe, Devon.
78	Cherry Norman ..	15/11/32	1.049	0.21	0.25	5.5	5/1/33	1.025	W. R. Thomas, Nunnington, Her.
79	Cherry Norman ..	15/11/32	1.050	0.21	0.24	4.5	7/1/33	1.025	J. E. Edwards, Norton Canon, Her.
80	Knotted Kernel ..	18/11/32	1.061	0.28	0.39	5.5	2/1/33	1.025	" "
81	French ..	5/12/32	1.050	0.28	0.42	10.0	29/12/32	1.025	E. Newman, Manson, Mon.
82	French ..	5/12/32	1.048	0.26	0.33	9.0	2/1/33	1.025	A. L. Thomas, Manson, Mon.
83	French ..	5/12/32	1.050	0.31	0.42	8.5	31/12/32	1.025	D. A. & R. R. Watkins, Rockfield, Mon.
84	Counseller (French) ..	5/12/32	1.051	0.33	0.36	8.0	31/12/32	1.025	T. Fawkes, Stonehouse, Glos.
85	French ..	5/12/32	1.050	0.29	0.42	8.5	2/1/33	1.025	J. E. Bradley, Rockfield, Mon.
86	Strawberry Norman ..	5/12/32	1.052	0.34	0.36	5.7	10/1/33	1.025	J. E. Edwards, Norton Canon, Her.
87	Yellow Norman ..	5/12/32	1.072	0.27	0.48	8.6	9/1/33	1.025	D. A. & R. R. Watkins, Rockfield, Mon.
88	Strawberry Norman ..	9/12/32	1.052	0.32	0.40	6.6	24/12/32	1.025	J. Bourne, Burghill, Her.

TABLE I.—*continued.*

CIDERS.

COMPETITION VARIETIES.

CLASS 4.—BITTERSWEET VARIETIES—*contd.*

89	Strawberry Norman	9/12/32	1.048	0.30	0.32	6.6	27/12/32	1.025	1.023	J. E. Bradley, Rockfield, Mon.
90	Médaille d'Or ..	9/12/32	1.047	0.25	0.38	6.3	9/1/33	1.025	1.024	W. Wootton, Byford, Her.
91	Green Bittersweet	9/12/32	1.046	0.22	0.25	5.6	3/1/33	1.025	1.023	G. Williams & Son, Westhide, Her.
92	Royal Jersey ..	16/12/32	1.052	0.33	0.35	4.3	16/2/33	1.025	1.023	H. E. Dabinett, Somerton, Som.
93	White Norman ..	24/10/32	1.053	0.26	0.36	5.8	28/11/32	1.025	1.024	W. R. Thomas, Nunnington, Her.

CLASS 5.—THE CIDERS IN THIS CLASS ARE BLENDS MADE AT THE INSTITUTE FROM THE RESPECTIVE ENTRIES OF INDIVIDUAL COMPETITORS IN CLASSES 1—4. From each competitor's set of single variety Ciders, two blends, A and B, have been prepared in proportions selected by the competitor himself (A) and by the Institute (B) respectively. The numbers in brackets are those of the single variety Ciders in the preceding Classes used for the blends.

94A	Frederick (12)—1, Perthyre (68)—1, Rockfield Cummy (49)—1, Early Sweet (48)—1 ..	..	..	0.61	0.20	..	..	..	1.023	G. Breakwell, Perthyre, Mon.
94B	Frederick (12)—1, Perthyre (68)—1, Rockfield Cummy (49)—1, Early Sweet (48)—1, White Sharp (37) —1, Breakwell's Seedling (22)—1	..	..	0.61	0.20	..	..	..	1.026	G. Breakwell, Perthyre, Mon.
95A	Frederick (11)—7, Strawberry Nor- man (89)—4, Perthyre (64)—4	..	..	0.76	0.23	..	..	..	1.025	J. E. Bradley, Rockfield, Mon.
95B	Frederick (11)—1, Strawberry Nor- man (89)—1, Perthyre (64)—2	..	..	0.54	0.25	..	..	..	1.024	J. E. Bradley, Rockfield, Mon.

TABLE I.—*continued*.

CIDERS.

COMPETITION VARIETIES.

No.	Name of Variety.	Date of making.	Specific Gravity of Fresh Juice.	Malic Acid per cent.	Tannin per cent.	Rate of fermentation.	Date of Filtering.	Specific Gravity at time of Filtering.	Specific Gravity of May, 1933.	Name and Address of Grower.
CLASS 5.—THE CIDERS IN THIS CLASS ARE BLENDS MADE AT THE INSTITUTE, ETC.— <i>contd.</i>										
96A	Frederick (14)—1, Perthyre (69)—3	..	..	0.60	0.22	..	..	..	1.026	Captain Beer, Llanvair, Mon.
96B	Frederick (14)—1, Perthyre (69)—4	..	..	0.58	0.22	..	..	..	1.024	Captain Beer, Llanvair, Mon.
97A	Wyatt's Seedling (34)—2, Sweet	..	..	0.60	0.15	..	..	..	1.028	W. J. Berry, Newton St. Cyres, Devon
97B	Wyatt's Seedling (34)—3, Sweet	..	..	0.61	0.14	..	..	..	1.028	W. J. Berry, Newton St. Cyres, Devon.
98A	Golden Ball (43) —1, Best Bearer	..	..	0.58	0.20	..	..	..	1.028	J. Bowditch, Stoke Abbott, Dorset.
98B	Golden Ball (43) —2, Best Bearer	..	..	0.57	0.22	..	..	..	1.027	J. Bowditch, Stoke Abbott, Dorset.
99A	Langworthy (33) —1, Woodbine	..	..	0.55	0.16	..	..	..	1.026	E. T. Bryant, Taunton, Som.
99B	Langworthy (33) —2, Woodbine	..	..	0.57	0.15	..	..	..	1.027	E. T. Bryant, Taunton, Som.

TABLE I.—*continued.*

CIDERS.

COMPETITION VARIETIES.

CLASS 5.—THE CIDERS IN THIS CLASS ARE BLENDS MADE AT THE INSTITUTE, ETC.—*conid.*

100A Sour Cluster (45) —4, Pound Apple (50)—1 ..	..	0.66	0.25	..	..	1.027	Mrs. Clarke, Honiton, Devon.
100B White Sheep's Nose (32)—1, Pound Apple (50) —1 ..	..	0.57	0.24	..	..	1.024	Mrs. Clarke, Honiton, Devon
101A Frederick (16)—1, Perthrye (70)—2 ..	..	0.66	0.24	..	..	1.025	E. M. Cowles, Hendre, Mon.
101B Frederick (16)—1, Perthrye (70)—4, Red Sharp (39)—1 ..	..	0.57	0.22	..	..	1.024	E. M. Cowles, Hendre, Mon.
102A Kingston Black (8) —1, Royal Jersey (92)—2 ..	..	0.59	0.35	..	..	1.026	H. E. Dabinett, Somerton, Som.
102B Kingston Black (8) —2, Royal Jersey (92)—5 ..	..	0.58	0.38	..	..	1.025	H. E. Dabinett, Somerton, Som.
103A Kingston Black (4) —1, Knotted Kernel (80)—1, Cherry Norman (79)—1 ..	..	0.54	0.32	..	..	1.025	J. E. Edwards, Norton Canon, Her.
103B Kingston Black (4) —3, Knotted Kernel (80)—2, Cherry Norman (79)—4 ..	..	0.53	0.31	..	..	1.026	J. E. Edwards, Norton Canon, Her.

TABLE I.—*continued.*

COMPETITION VARIETIES.

CIDERS.

No.	Name of Variety.	Date of making.	Specific Gravity of Fresh Juice.	Malic Acid per cent.	Tannin per cent.	Rate of fermentation.	Date of Filtering.	Specific Gravity at time of May, Filtering. 1933.	Name and Address of Grower.
CLASS 5.—THE CIDERS IN THIS CLASS ARE BLENDS MADE AT THE INSTITUTE, ETC.— <i>conid.</i>									
104A	Kingston Black (3) —1, Woodbine (71)—1, Clusters (73)—1 ..	..	..	0.60	0.35	..	..	..	1.026 W. Hill, Kittisford, Som.
104B	Kingston Black (3) —2, Woodbine (71)—2, Clusters (73)—1, Crimson King (38)—1 ..	..	..	0.66	0.23	..	..	..	1.026 W. Hill, Kittisford, Som.
105A	Berkeley Pippin (55)—2, Hunt's White Sharp (41) —1 ..	..	..	0.43	0.16	..	..	..	1.024 W. Hunt, Easton-in-Gordano, Som.
105B	Berkeley Pippin (55)—2, Hunt's White Sharp (41) —3 ..	..	..	0.45	0.17	..	..	..	1.025 W. Hunt, Easton-in-Gordano, Som.
106A	Frederick (17)—1, Belle Norman (Perthyre) (66) —2 ..	..	..	0.58	0.17	..	..	..	1.023 R. P. Jones, Monmouth, Mon.

TABLE 1.—*continued.*

CIDERS.		COMPETITION VARIETIES.				
CLASS 5.—THE CIDERS IN THIS CLASS ARE BLENDS MADE AT THE INSTITUTE, ETC.— <i>contd.</i>						
106B	Frederick (17)—1, Belle Norman (Perthyre) (66) —3	..	0.52	0.17	..	1.023 R. P. Jones, Monmouth, Mon.
107A	Frederick (19)—1, Perthyre (62)—2	..	0.59	0.19	..	1.024 S. J. Mullins, Dingestow, Mon.
107B	Frederick (19)—1, Perthyre (62)—3	..	0.54	0.20	..	1.024 S. J. Mullins, Dingestow, Mon.
108A	Sour Natural (35) —5, Sweet Alford (54)—3	..	0.56	0.15	..	1.027 A. Pope, Crediton, Devon.
108B	Sour Natural (35) —1, Sweet Alford (54)—1	..	0.52	0.15	..	1.026 A. Pope, Crediton, Devon.
109A	Kingston Black (6) —1, Cherry Nor- man (78)—2	..	0.48	0.26	..	1.026 W. R. Thomas, Nunnington, Her.
109B	Kingston Black (6) —1, Cherry Nor- man (78)—1, Cummy Norman (74)—1	..	0.48	0.24	..	1.027 W. R. Thomas, Nunnington, Her.
110A	Colman's (40)—1, Sweet Woodbine (59)—2	..	0.56	0.17	..	1.025 H. Walters, Newton St. Cyres, Devon.
110B	Colman's (40)—1, Sweet Woodbine (59)—1	..	0.58	0.13	..	1.026 H. Walters, Newton St. Cyres, Devon.

TABLE I.—*continued.*
COMPETITION VARIETIES.

No.	Name of Variety.	Date. of making.	Specific Gravity of Fresh Juice.	Malic Acid per cent.	Tannin per cent.	Rate of fermen- tation.	Date of Filtering.	Specific Gravity at time of May, Filtering, 1933.	Name and Address of Grower.
CLASS 5.—THE CIDERS IN THIS CLASS ARE BLENDS MADE AT THE INSTITUTE, ETC.— <i>contd.</i>									
111A	Kempley Red (29) —1, Médaille d'Or (90)—2 ..	..	..	0.54	0.29	..	..	1.025	W. Wootton, Byford, Her.
111B	Kempley Red (29) —3, Médaille d'Or (90)—2 ..	..	..	0.68	0.23	..	..	1.026	W. Wootton, Byford, Her.
112A	Normans (36)—7, Green Bitter- sweet (91)—3 ..	..	..	0.57	0.21	..	..	1.025	G. Williams & Son, Westhild, Her.
112B	Normans (36)—4, Green Bitter- sweet (91)—1 ..	..	..	0.60	0.19	..	..	1.025	G. Williams & Son, Westhild, Her.
113A	Yellow Norman (87)—1, Perthyre (65)—1, Frederick (13)—1, Rockfield Cummy (75)—1, French (83)—1, Styre (24)—1 ..	..	..	0.62	0.22	..	..	1.022	D. A. & R. R. Watkins, Rockfield, Mon.
113B	Yellow Norman (87)—2, Frederick (13)—1, Rockfield Cummy (75)—3, Strawberry Red (30)—1 ..	..	..	0.56	0.22	..	..	1.023	D. A. & R. R. Watkins, Rockfield, Mon.

TABLE I.—*continued.*

PERRIES.		COMPETITION VARIETIES.									
CLASS 6.—PERRIES.											
114	Long Pear	..	4/11/32	1.048	0.61	0.09	7.7	15/11/32	1.030	1.027	T. Fawkes, Stonehouse, Glos
115	Blakeney Red	..	4/11/32	1.043	0.47	0.09	4.3	17/11/32	1.030	1.029	J. E. Bradley, Rockfield, Mon.
116	Blakeney Red	..	4/11/32	1.044	0.46	0.07	3.0	21/11/32	1.030	1.028	H. A. Lane, Chaceley, Worcs.
117	Blakeney Red	..	4/11/32	1.047	0.52	0.06	4.5	28/11/32	1.030	1.028	R. Hyett, Dymock, Glos.
118	Green Pear	..	7/11/32	1.048	0.52	0.15	7.0	22/11/32	1.030	1.028	T. H. Brookes, Uckington, Glos.
119	Oldfield	..	28/11/32	1.050	0.46	0.10	7.7	16/12/32	1.030	1.024	T. H. Brookes, Uckington, Glos.
CIDERS AND PERRY MADE FROM SINGLE VARIETIES SENT FOR TRIAL.											
120	Blakeney Red	..	4/11/32	1.040	0.36	0.10	4.7	17/11/32	1.030	1.028	W. Wootton, Byford, Her.
121	Brown Snout	..	9/12/32	1.056	0.29	0.17	9.0	2/1/33	1.025	1.022	H. A. Lane, Chaceley, Worcs.
122	Médaille d'Or	..	9/12/32	1.056	0.20	0.26	5.5	11/1/33	1.025	1.024	Williams Bros., Backwell, Som.
123	Late Cider Variety	..	9/12/32	1.049	0.21	0.15	6.5	10/1/33	1.025	1.024	W. P. Martell, Usk, Mon.
124	France	..	15 12/32	1.048	0.35	0.17	8.5	2/1/33	1.025	1.023	Jersey.
CIDERS MADE FROM THE LONG ASHTON TRIAL ORCHARDS.											
125	Dabinett	..	28/12/32	1.051	0.29	0.28	6.5	12/1/33	1.025	1.024	Long Ashton Trial Orchard.
126	Knotted Kernel	..	9/12/32	1.053	0.20	0.29	5.4	13/1/33	1.025	1.024	"
127	Lambrook Pippin	..	4/1/33	1.036	0.62	0.22	5.0	11/1/33	1.030	1.030	"
128	Mixed Bittersweets	..	1/12/32	1.045	0.30	0.29	4.4	4/1/33	1.025	1.025	"

TABLE II.

COMPETITION CIDERS AND PERRIES, 1932-33.

JUDGES' AWARDS.

CIDERS.

Class 1.		No.	KINGSTON BLACK. (8 Entries).	
First Prize	..	2	L. E. Guilding, Bushley, Wores.	
Second Prize	..	4	J. E. Edwards, Norton Canon, Her.	
Third Prize	..	3	W. Hill, Kittisford, Som.	
Fourth Prize	..	5	P. E. Bomford, Upton Snodsbury, Wores.	
Reserve		1	Major C. Jackson, Charlton Mackrell, Som.	
Highly Commended		6	W. R. Thomas, Nunnington, Her.	
"	"	7	J. Stead, Penhow, Mon.	
"	"	8	H. E. Dabinett, Somerton, Som.	
Class 2A.			SHARP VARIETIES. (Acidity 0.8% or above).	
			(13 Entries).	Variety.
First Prize	..	15	F. F. Scudamore, Nantyderi, Mon.	Frederick.
Second Prize	..	20	J. E. Bradley, Rockfield, Mon.	Rockfield Cowarne.
Third Prize	..	19	S. J. Mullins, Dingestow, Mon.	Frederick.
Fourth Prize	..	13	D. A. & R. R. Watkins, Rockfield, Mon.	Frederick.
Reserve		10	B. Williams, Llanllowell, Mon.	Frederick.
Commended	..	9	G. Breakwell, Perthyre, Mon.	Redstreak.
"	..	11	J. E. Bradley, Rockfield, Mon.	Frederick.
Class 2B.			MEDIUM SHARP VARIETIES. (Acidity below 0.8%).	
			(25 Entries).	
First Prize	..	26	Major Jackson, Charlton Mackrell, Som.	Jackson's White.
Second Prize	..	35	A. Pope, Crediton, Devon	Sour Natural (Langworthy).
Third Prize	..	24	D. A. & R. R. Watkins, Rockfield, Mon.	Styre.
Fourth Prize	..	38	W. Hill, Kittisford, Som. . .	Crimson King.
Reserve		39	E. M. Cowles, Hendre, Mon. . .	Red Sharp.
Highly Commended		41	W. Hunt, Easton-in-Gordano, Som.	Hunt's White Sharp.
Commended	..	31	J. Halse & Sons, Newton St. Cyres, Devon	Sour Natural (Langworthy).
"	..	33	E. T. Bryant, Taunton, Som.	Langworthy.
"	..	34	W. J. Berry, Newton St. Cyres, Devon	Wyatt's Seedling (Langworthy).
"	..	40	H. Walters, Newton St. Cyres, Devon	Colmans.
"	..	43	J. Bowditch, Stoke Abbott, Dorset	Golden Ball.

*Class 3.*SWEET VARIETIES. (30 *Entries*).

First Prize	.. 53	W. J. Berry, Newton St. Cyres, Devon	Sweet Alford.
Second Prize	.. 55	W. Hunt, Easton-in-Gordano, Som.	Berkeley Pippin.
Third Prize	.. 57	S. Cursons, Dunsford, Devon	Sweet Alford.
Fourth Prize	.. 60	E. T. Bryant, Taunton, Som.	Woodbine.
Reserve ..	.. 72	J. Bourne, Burghill, Her. ..	Belle Norman (Perthyre).
Commended	.. 49	G. Breakwell, Perthyre, Mon.	Rockfield Cummy.
„	.. 51	J. Peek, Ottery St. Mary, Devon	Sweet Alford.
„	.. 52	W. G. Bradley, Tregare, Mon.	Willow Apple.
„	.. 54	A. Pope, Crediton, Devon ..	Sweet Alford.
„	.. 56	F. Vincent, Pinhoe, Devon	Sweet Alford.
„	.. 58	J. Bowditch, Stoke Abbott, Dorset	Best Bearer
„	.. 59	H. Walters, Newton St. Cyres, Devon	Sweet Woodbine.
„	.. 61	W. G. Bradley, Tregare, Mon.	Perthyre.
„	.. 64	J. E. Bradley, Rockfield, Mon.	Perthyre.
„	.. 67	A. T. Blake & Sons, Monmouth, Mon.	Perthyre.
„	.. 69	Capt. Beer, Llanvair, Mon.	Perthyre.
„	.. 70	E. M. Cowles, Hendre, Mon.	Perthyre.
„	.. 71	W. Hill, Kittisford, Som. ..	Woodbine.
„	.. 73	W. Hill, Kittisford, Som. ..	Clusters.
„	.. 74	W. R. Thomas, Nunnington, Hereford	Cummy Norman.
„	.. 75	D. A. & R. R. Watkins, Rockfield, Mon.	Rockfield Cummy.
„	.. 76	S. W. Jones, Tregare, Mon. ..	Red Norman.

*Class 4.*BITTERSWEET VARIETIES. (17 *Entries*).

First Prize	.. 78	W. R. Thomas, Nunnington, Hereford	Cherry Norman.
Second Prize	.. 79	J. E. Edwards, Norton Canon, Hereford	Cherry Norman.
Third Prize	.. 88	J. Bourne, Burghill, Her. ..	Strawberry Norman.
Fourth Prize	.. 77	F. Vincent, Pinhoe, Devon ..	Tremlett's Bitter.
Reserve ..	.. 86	J. E. Edwards, Norton Canon, Hereford	Strawberry Norman.
Commended	.. 87	D. A. & R. R. Watkins, Rockfield, Mon.	Yellow Norman.
„	.. 89	J. E. Bradley, Rockfield, Mon.	Strawberry Norman.
„	.. 90	W. Wootton, Byford, Her. ..	Médaille d'Or.
„	.. 91	G. Williams & Son, Westhide, Hereford	Green Bittersweet.
„	.. 92	H. E. Dabinett, Somerton, Som.	Royal Jersey.
„	.. 93	W. R. Thomas, Nunnington, Her.	White Norman.

Class 5.

BLENDS. (40 Entries).

First Prize	..	107A	S. J. Mullins, Dingestow, Mon.	
Second Prize	..	108A	A. Pope, Crediton, Devon.	
Third Prize	..	107B	S. J. Mullins, Dingestow, Mon.	
Fourth Prize	..	101B	E. M. Cowles, Hendre, Mon.	
Reserve	..	105A	W. Hunt, Easton-in-Gordano, Som.	
Highly Commended		104A	W. Hill, Kittisford, Som.	
Commended	..	94A	G. Breakwell, Perthyre, Mon.	
„	..	94B	G. Breakwell, Perthyre, Mon.	
„	..	95A	J. E. Bradley, Rockfield, Mon.	
„	..	95B	J. E. Bradley, Rockfield, Mon.	

Class 6.

PERRIES. (6 Entries)

First Prize	..	118	T. H. Brookes, Uckington, Glos.	Green Pear.
Second Prize	..	115	J. E. Bradley, Rockfield, Mon.	Blakeney Red.
Third Prize	..	114	T. Fawkes, Stonehouse, Glos.	Long Pear.
Fourth Prize	..	119	T. H. Brookes, Uckington, Glos.	Oldfield.
Reserve	..	116	H. A. Lane, Chaceley, Worcs.	Blakeney Red.

EXPERIMENTS ON THE IMPROVEMENT OF THE JUICE FROM CULINARY AND DESSERT APPLES BY MACERATION WITH PRESSED BITTERSWEET POMACE.

PROGRESS REPORT.

By P. T. H. PICKFORD.

The problem of utilisation of the lower grade market apples for cider making becomes increasingly important as the demand for high quality fruit increases, and grading and marketing methods advance.

Previous trials have shown that it is possible for the cider industry to utilise a considerable proportion of "culls" from commercial growers and to produce a palatable beverage from them, provided that sufficient cider apples of the "sweet" and "bittersweet" types can be procured to blend with them.

Market varieties generally yield a juice of relatively low sugar and tannin content while the acidity is usually too high. The resulting cider is often thin and lacking in character, with a coarse acid flavour and usually poor colour. Moreover, their juices are, as a rule, very rapid in fermentation compared with juices from cider varieties, thus making the process more difficult to control.

The blending of approximately equal parts of "bittersweet" cider apples with market varieties normally produces a very palatable beverage. The "bittersweet" type, which is high in sugar and tannin content and relatively low in acidity, balances the lack of sugar and tannin and the excess of acidity in the market varieties. Admixture with this class of cider varieties also generally considerably retards the rate of fermentation.

The problem of the utilisation of market sorts for cider making becomes acute where it is impossible to procure sufficient bittersweet cider apples to blend in the proportions stated above, and it is often difficult for the cider maker to obtain an adequate quantity of bittersweets to use in this way.

Experimental.

With the object of obtaining more of the bittersweet character out of "bittersweet" cider apples and so reducing the proportion of bittersweets necessary to suitably modify market varieties, a series of experiments was commenced in 1932 on the possible improvement of juice from culinary and dessert apples by maceration with once-pressed bittersweet pomace.

The market varieties taken were Bramley's Seedling, Newton Wonder and Allington Pippin. The treatment in each case was to re-soak the once-pressed pomace from approximately 10 cwts. of bittersweet apples with the juice obtained from an equivalent weight of the market varieties. The detailed treatments given and the analyses of the juices are shown in the table on page 188.

In the case of the Bramley's Seedling juice which was allowed to macerate with Knotted Kernel pomace for 12 hours, it will be seen that the specific gravity was considerably increased after the treatment and acidity was appreciably lowered, but the tannin showed only a slight increase. The rate of fermentation of the treated juice was rather quicker than that of the untreated juice, but the latter had an exceptionally slow rate of fermentation for this type of juice, and was even slower than the Knotted Kernel juice. Where the Bramley's Seedling juice was allowed to macerate with Knotted Kernel pomace for 24 hours the increase in the specific gravity and the decrease in the acidity were not so marked as in the case of the 12 hours treatment, and the tannin showed a very considerable decrease. The rate of fermentation, however, in this case, was shown to be slower.

Treatment of the juice from Newton Wonder with Royal Jersey pomace brought about a similar effect on the specific gravity and the acidity as maceration with Knotted Kernel pomace had on the Bramley's Seedling for this period. A decrease in the tannin is shown here and a very slight increase in the rate of fermentation.

In the case of the Allington Pippin juice, the specific gravity of this was slightly higher than that of the mixed bittersweets, and thus no increase would be expected after treatment. The rather low gravity of the Bittersweet juice can be accounted for from the fact it was obtained from apples from comparatively young trees. The effect of maceration on the acidity of the Allington Pippin juice was the same as in the former cases. The tannin value was again decreased and the rate of fermentation showed an increase.

The change in the bittersweet character of the juice after maceration was the most interesting feature in the experiments. Although

a decrease in tannin value, due to oxidation during maceration, is shown on analysis in all cases except one, yet a very marked increase in bittersweet character was actually found in the flavour of all the macerated samples.

The rate of fermentation in the cider house of all the juices—as distinct from the laboratory test—is shown by the filtering dates given in Table I. Taking the average fall in gravity per day there was very little difference between the rate of fermentation of the treated and untreated juices.

The samples were examined some months after making and in each case a distinct alteration in the flavour of the market varieties had been brought about by maceration with the bittersweet pomace. The flavour and colour were considerably improved, and ciders with definitely more body and character resulted from the treatment. The only case where the beneficial effect was not so marked was that of Bramley's Seedling, allowed to soak for 24 hours.

It is proposed to extend the experiments next season in order to compare the results of various other possible methods of re-soaking and macerating bittersweet pomace with those described above.

TABLE I.

<i>Variety.</i>	<i>Treatment of Juice.</i>	<i>Date of making.</i>	<i>Specific Gravity of fresh juice.</i>	<i>Malic Acid per cent.</i>	<i>Tannin per cent.</i>	<i>Rate of fermentation.</i>	<i>Date of filtering.</i>	<i>Specific Gravity at time of filtering.</i>	<i>Specific Gravity May, 1933.</i>
Bramley's Seedling	Untreated	18/11/32	1.044	0.94	0.18	5.0	3/12/32	1.030	1.030
do.	Macerated with Knotted Kernel pomace for 12 hours	18/11/32	1.049	0.69	0.19	5.7	14/12/32	1.030	1.029
do.	Macerated with Knotted Kernel pomace for 24 hours	18/11/32	1.046	0.71	0.09	5.0	10/12/32	1.030	1.030
Knotted Kernel	Untreated	18/11/32	1.061	0.28	0.39	5.5	2/1/33	1.025	1.024
Newton Wonder	Untreated	16/12/32	1.040	0.60	0.08	5.0	28/12/32	1.030	1.027
do.	Macerated with Royal Jersey pomace for 12 hours	16/12/32	1.045	0.47	0.06	5.2	2/1/33	1.030	1.028
Royal Jersey	Untreated	16/12/32	1.052	0.33	0.35	4.3	16/2/33	1.025	1.023
Allington Pippin	Untreated	1/12/32	1.046	0.66	0.10	5.2	12/12/32	1.030	1.024
do.	Macerated with Mixed Bittersweets pomace for 12 hours	1/12/32	1.046	0.56	0.07	6.3	19/12/32	1.030	1.026
Mixed Bittersweets	Untreated	1/12/32	1.045	0.30	0.29	4.4	4/1/33	1.025	1.025

FERMENTATION CONTROL OF CIDERS BY THE CENTRIFUGE METHOD.

By VERNON L. S. CHARLEY.

The original experiments (1, 2) carried out in the 1929-30 and 1930-31 cider-making season on the use of the super-centrifuge for clarification and control of fermentation of cider indicated in a general way the possibilities of this method of treatment. Since that time, the centrifuge has become more common in cider factories, and its more extended use has quite naturally brought with it several problems affecting the actual procedure to be adopted in the various situations arising during the active making season. Prominent amongst these is the question of choosing the correct time to use the machine in order to gain maximum control over the fermenting medium.

To ensure the maximum efficiency from the centrifuging of cider, it is necessary to understand the factors which influence the clarification and checking of fermentation. Previous work carried out at this station, to which reference is made above, has been concerned mainly with the use of the centrifuge at the gravity at which it was desired to maintain the cider. But in the earlier weeks of the season, when the temperatures are inclined to be comparatively high, the fermentations are relatively rapid, and more cider may be simultaneously ready for treatment than the machine capacity available can cope with. The question arises whether or no appropriate treatment at some higher gravity will sufficiently retard yeast action, and allow of more leisured and complete treatment at the gravity ultimately desired.

It has been a matter of general knowledge since the introduction of the centrifuge that the higher the gravity of the cider treated, the less satisfactory is the control achieved over the fermentation. Routine work on a commercial scale in the Ciderhouse at Long Ashton has indicated that ciders centrifuged at a gravity of 1.030 and below rarely lose more than two or three points in gravity during the ensuing six months, whilst ciders treated at higher gravities undergo correspondingly greater after-fermentation.

The experiments described in this paper were carried out in the 1932-33 cider-making season, as a preliminary to the extensive study of the factors concerned with the effective use of the centrifuge for clarification and fermentation control.

Experimental.

The juice used for the experiments was obtained from a consignment of apples from Northern Ireland, consisting mainly of low-grade Bramley's Seedling. On arrival, the fruit was found to consist of a mixture of about 70 per cent. of culinary fruit, together with 30 per cent. of cider-type apples, this admixture of the latter resulting in a slower fermentation than had been desired. The juice was expressed on January 13th, 1933, and was received into five 30-gallon casks. One cask of juice was immediately centrifuged (specific gravity 1.037), and a further cask was treated in a similar manner at each of the following gravities: 1.030, 1.025, 1.017, 1.007. The juice obtained by centrifuging the fresh juice (gravity 1.037) was again passed through the machine when the gravity had fallen to 1.032, whilst the cider originally centrifuged at a gravity of 1.030 was again treated at 1.025. These two ciders were the only cases in which double centrifuging was applied for fermentation control, since in the ciders centrifuged at lower gravities complete control was achieved with a single treatment.

The centrifuged ciders were stored in 18-gallon casks, cleaned in the usual way with steam, and were tightly bunged down until the last observations on gravity were made.

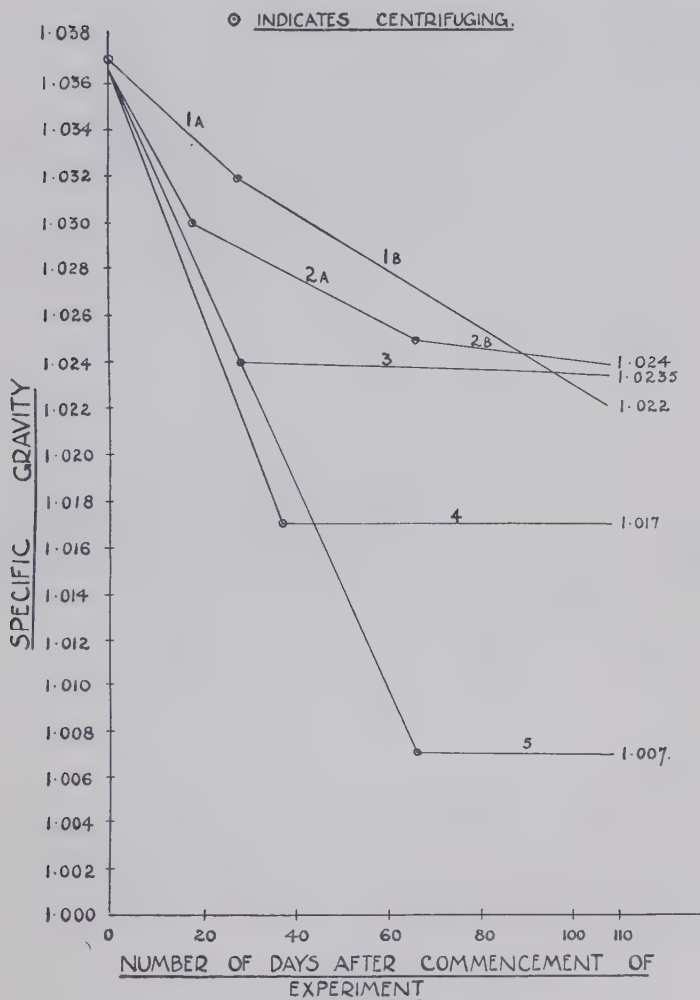
The fresh juice and the ciders in the casks, before and after each treatment with the centrifuge, were examined microscopically for indications of the effect of such treatments on the yeast population. In the case of the casks of fermenting cider about to be centrifuged, a sample was taken by means of a sterile rubber tube from the middle of the cask. The large number of yeasts in the lees were not considered, as the centrifuge was stopped before these were pumped over into the machine. Samples from the centrifuged material were taken in sterile test tubes directly from the outlet of the centrifuge, and examined immediately.

The data are graphically reproduced on page 147.

The observations on the yeast populations of the various samples are tabulated below.

No. 1. *Uncentrifuged Fresh Juice.* The fresh juice contained a large number of yeasts of varying shapes and sizes. The predominant type, however, was spherical, with 4.4μ

EFFECT OF CENTRIFUGING CIDERS AT VARIOUS GRAVITIES ON FERMENTATION CONTROL.



diameter, whilst the remainder varied between $4\mu \times 3\mu$ and $11\mu \times 4\mu$. Many yeasts were in the early budding stage.

No. 1a. *Centrifuged Fresh Juice.* A sample, taken 5 minutes after the centrifuge had commenced, showed a remarkable diminution of yeasts, whilst those remaining in the juice were much smaller, in the average, than those in control juice. No yeasts larger than the spherical type (diameter 4.4μ) were present, it being at once apparent that there had been complete removal of the larger sized cells. A few small spherical yeasts were present, and these had the appearance of buds which had become dissociated from their parent cells. A further sample, taken immediately before the cessation of centrifuging, *i.e.* after a 25 minute period, contained a similarly small number of yeasts with appreciably similar characters.

No. 1b. *Second Centrifuging of No. 1a.* After 28 days, the juice which had been centrifuged in a fresh condition had fallen 5 points in gravity. The material in the body of the cask was examined microscopically, and again after centrifuging. In the former case there were noticeably fewer yeasts present than in the fresh untreated juice, but the average size was very similar. In the centrifuged samples, the number of yeast-like cells were again considerably reduced, their dimensions resembling those observed in the original centrifuged samples.

No. 2a. *First Centrifuging of Cider of Gravity 1.030.* The fermenting cider again contained a large number of yeasts, but the larger types mentioned above in connection with No. 1a, were absent. After centrifuging, there were a small number of yeasts, practically all identical in size and shape (diameter 4.4μ).

No. 2b. *Second Centrifuging of No. 2a.* The yeasts present in the cider of gravity 1.025, were similar in number to the analogous sample No. 1b. After centrifuging, the predominant yeasts were again spherical cells with a diameter of 4μ .

No. 3. *First and Only Centrifuging of Cider of Gravity 1.024.* A very noticeable diminution of yeasts in the fermenting cider was noticed. The cells were mainly spherical, and again with the familiar diameter of 4μ , with just a few very small yeast-like bodies, suggestive of buds mechanically severed from their parent cells. After passage through the

centrifuge, the few cells remaining were spherical, with diameters between $2\text{-}5\mu$.

No. 4. *First and Only Centrifuging of Cider of Gravity 1.017.*

A further drop in the number of yeasts present in the control cask was apparent. Their size was practically uniform ($5\mu \times 4\mu$), and whilst the size of the cells surviving centrifugation was similar to those in the untreated juice, the number of the former was very small.

No. 5. *First and Only Centrifuging of Cider of Gravity 1.007.*

In this, the last sample cask to be centrifuged, the yeasts were observed to be somewhat in excess of those found in the analogous sample at gravity 1.017. Some larger cells were apparent (several with dimensions of $10\mu \times 4\mu$), and it is probable that barometric disturbances in the atmosphere had caused an evolution of gas from the lees, with a consequent agitation of the yeast deposit. The centrifuged samples were similar to those of the previous sample.

Discussion.

Several points of interest emerge from a critical examination of the preceding experiments.

Consideration of the effect of centrifugation of cider at differing gravities, as indicated by the experimental results, permits the the following statements to be made:—

- (1) The fermentation control increased in efficiency as the gravity of the treated ciders became lower.
- (2) Practically complete fermentation control was obtained at a gravity of 1.024 by a single centrifuging.
- (3) Complete cessation of fermentation was effected by treatments at 1.017 or 1.007.

The above forms a concise statement of the outcome of the experiment, but some amplification of one or two of the points is desirable.

One of the objects of the experiments was to discover the most suitable point of the fermentation period at which to utilise the centrifuge to procure maximum fermentation control. At first sight, it might seem natural that the removal of a considerable percentage of the yeasts from the fresh juice would have a potent effect on the subsequent fermentation. This, however, has been shown to be fallacious, not alone by the data obtained during the course of this experiment, but by a number of similar isolated trials carried out in connection with other lines of work. The fact that the centrifuge removed approximately the same large proportion of yeast cells

from the fresh juice as from the lower gravity ciders, indicates that some other factor than the mere numerical strength of the yeast population is influencing the rate of fermentation. It is probable that the whole problem is intimately associated with the removal of nitrogen from the juice by means of an actively growing yeast crop. As the yeasts which are originally present in the fresh juice multiply, their nitrogenous needs will be supplied solely from the nitrogen constituents in the juice, and in this way a quantity of nitrogen from the juice is "fixed" in the protoplasm of the yeast cells. It will be seen that it is not sufficient merely to remove a large number of yeast cells. The yeasts originally present have in no way exhausted the nitrogen resources of the juice, and their removal cannot affect the percentage of nitrogen remaining after centrifugation. But, on the other hand, the centrifuging of a cider in full fermentation, where the bulk of the yeasts have propagated in the cider, and have developed at the expense of the nitrogen in the juice, will result not only in a removal of the yeast cells, but also in a simultaneous withdrawal of a considerable quantity of nitrogen from the fermenting medium. The centrifuged cider will then be impoverished with respect to nitrogen and the fermenting action of the yeasts remaining in the cider will be correspondingly reduced.

It is evident from the above, that the effect that is being sought by means of the centrifuge can only be obtained after a certain fall in gravity has occurred. The exact extent of this fall which is essential before the centrifuge can be used to fullest advantage will certainly vary according to the nature of the juice and its original gravity, but the data so far obtained suggest that a loss of from 8-12 points of gravity is necessary for the development of a sufficiently large crop of yeasts. Definite proof of this very important influence of nitrogen content on centrifugal control of fermentation can come only from actual analyses of the nitrogen percentages of the juices and ciders before and after a series of centrifugings; this has been carried out during the 1933-34 season, but as the necessary analytical work is still incomplete, the experiments will be discussed in a later Report.

It is unfortunate that the material from which the juice was prepared for the above experiments, and which was especially chosen in the expectation of a high rate of fermentation, did not actually ferment at all quickly. This will be appreciated from the fact that the two double centrifugings were separated by periods of 30 and 40 days respectively—a comparatively long period in works practice. However, it is clear from the graphs, that with a juice of medium rate of fermentation, double centrifuging at

gravities of 1.037 and 1.032 in one case, and at 1.030 and 1.025 in the other, have not afforded any better control than a single treatment at 1.024. This observation tends to confirm the above suggestion that it is necessary to have a substantial fall in gravity from that of the fresh juice before any considerable degree of fermentation control is assured by the centrifuge.

Turning now to the observations concerning the yeast populations of the various ciders, the following facts have been shown :—

- (1) Centrifugation of the fresh juice gave an equally effective removal of yeast cells as in the later cases of fermenting juices, but in the first case the fermentation control was less.
- (2) Centrifuging effects a very considerable reduction in the number of yeast cells present.
- (3) A specific removal by the centrifuge of the larger types of yeasts has been observed.
- (4) The yeast cells contained in the bulk of the liquid exhibit a definite tendency to decrease in numbers during fermentation after the first period of very active evolution of gas has subsided.

Actual counts of yeasts were not carried out in the first instance, the differences mentioned in the above experimental section being decided and obvious to the eye. However, exact counts have been made during the 1933-34 season experiment mentioned above, and these, in general, agree with the above conclusions.

The diminution of yeast cells in the bulk of cider which was allowed to remain perfectly still for the duration of the experiment, was quite natural; the larger types of yeasts, by reason of purely physical forces, had gravitated to the bottom of the cask to settle amongst the lees.

The action of the centrifuge in removing the large-celled yeasts, is again the result of a natural physical phenomenon, and was to be expected. The regularity of the size of the yeasts passing through the centrifuge was remarkable and was recurrent in the various series of treatments.

The explanation of the "inactivation" of the yeasts which pass through the centrifuge, whether biological, chemical, or physical, is still unsettled. It is hoped that experiments in hand this season may throw some light on this problem.

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THE ACTION OF CIDER ON METALS.

By VERNON L. S. CHARLEY.

From the earliest days of the history of cider-making, the importance of preventing undue contact of cider with all forms of metallic surfaces has been recognised, and an urgent problem which has faced the makers of cider for the past 200 years has been the provision of suitable materials for lining presses, pipes and storage vessels used in cider-making operations. Even at the present day the problem is not satisfactorily solved, as will be evident from the experimental section of this report.

Not alone for their cheapness, convenience and well-known maturing properties have wooden vessels and implements been so long associated with cider-making practice, but the use of wood has been equally due to the fact that, suitably treated, it imparts no unpleasant flavour to the beverage stored in it, and the fruit acids, which exert such potent and undesirable effects on many metals and alloys, do not similarly corrode the wooden vessels with such disastrous results as is often the case with other types of containers.

The historical background of the subject under consideration is illustrated by the following passage from the "Herefordshire Pomona" (Volume I, page 138):—" . . . the juice of fruit will not dissolve the metal (*i.e.* iron or lead) unless it is left long in contact with it, but it will readily dissolve at once the dull grey powder which forms on the lead and the brown rust of iron, which are the oxides of the metals. while the salt formed, being quite soluble, is carried through the process of fermentation and remains in the cider. The salt of iron, if it were sufficiently strong to be injurious to health, would spoil the cider, so no more need be said of it; but the salt of lead is much more dangerous and since it sweetens the cider, it is not to be detected so easily. In almost all the cider districts the most painful cases of colic frequently occur from want of care to prevent any contact with lead. Sometimes the pulp is left in the mill for many days, when the lead is dissolved from the lead solderings of the clamps which connect the stones together; or again, when it is in a still more dangerous form, the lead is dissolved by the cider from the casks when white lead has been most improperly used by the cooper as caulking, to

prevent leakage. Or lastly, and this is perhaps the most frequent cause of all, the cider takes up lead from the cider engine at the bar tap, and the 'Boots,' who drinks the first jug drawn in the morning, instead of throwing it away, as is the general rule, gets a most serious illness. Too much care cannot be taken to prevent the contact of cider with lead, either in its manufacture or its preservation."

The early date of the above passage might lead to the supposition that such advice was now unnecessary, and such physical discomfort entirely a relic of mediaeval incompetence and ignorance. Unfortunately, this is not so. Instances of serious contamination derived from leaden pipes, or lead used to fill up cracks in the large stones used in the old fashioned type of mill, have been under the notice of the medical authorities within recent years, and it would appear that farm cider-makers still working under primitive conditions need to take very careful heed of such risks.

One of the difficulties associated with the problem is that of detection of contamination with metals. Lead can be dissolved in cider up to appreciable percentages before any indications are visible to afford a warning that solution of metal has occurred. Tin, and to a much lesser extent copper, behave similarly, and the first signs of the presence of excess metallic content are usually the physiological reactions of the consumer. With iron, the danger of unobserved attack is somewhat less, for most ciders are darkened by contact with this metal; in the case of astringent ciders, with high tannin contents, considerable darkening is immediately consequent upon contact with iron surfaces, the ultimate limit of which discolouration may be an ink-black, allied in appearance and chemical composition to ordinary ink. It is of interest to compare two statements relating to this aspect of the problem, the one contained in the above excerpt from the "Herefordshire Pomona," the other by Bryan of the Low Temperature Research Station, Cambridge (1). The two passages read: "The salt of iron, if it were sufficiently strong to be injurious to health, would spoil the cider, so no more need be said of it," and "It is indicated that foodstuffs contaminated with metals in common use would, as a rule, be offensive either to sight or taste long before they became dangerous to health." The implication inherent in the latter paragraph that foodstuffs which look and taste normal are safe for consumption from the metallic contamination point of view certainly holds in the case of tin and copper contaminated ciders, whilst the writer of the "Pomona" is on safe ground in his statement concerning dissolved iron.

One of the chief disadvantages, however, of ciders which contain

small quantities of dissolved metals, is the more or less conspicuous "metallic" flavour thereby acquired. Delicate palates are capable of detecting very small quantities of metallic impurities, and for this reason it is obvious that every possible care to prevent metallic contact with cider must be taken, else large quantities of otherwise perfect material may be completely spoilt from the flavour point of view. The usual qualitative chemical tests, however, often indicate the presence of tin, lead, copper or iron, when the metallic taste is not discernible on the palate, thus complicating the problem. Iron and copper impart characteristic metallic flavours to the ciders contaminated by their presence, and the occurrence of these metals in very small amounts is easily discovered on the palate. It is probably true to state that there is no danger whatever of unpleasant effects due to metal content following the drinking of ciders which do not possess this "metallic" flavour, and again, in view of the very small quantity of dissolved metal needed for the cider to acquire the contaminating flavour, it is equally true that many ciders in which this flavour is just apparent can be drunk with perfect safety.

The contact of metals with cider may occur at each or all of the processes connected with its manufacture or storage.

Fruits shovelled from one place to another with large iron implements are capable of carrying small quantities of rust through the milling stage, causing its ultimate solution by the acids of the juice. The mill itself, with the quickly revolving knife edges and the solid steel centre, offers a vulnerable surface to the juice. The nails used to manufacture the racks to support the clothes for pressing the milled pulp, are afforded every opportunity of yielding some metal to the juice. The common type of filter in use to-day, in which the metallic parts consist of copper with a heavy coating of tin, are fairly satisfactory until the tin commences to wear off. Once the underlying metal is largely exposed to the action of the cider, the solution of both copper and tin proceeds apace, and electro-chemical reactions hasten this undesirable effect. If metallic pipes are used for transference of cider from one vat or cask to another, the swiftly moving liquid is liable to remove small amounts of metal, and in this respect the use of lead in any shape or form is to be severely deprecated. The solving of some of these difficulties will be considered later in the light of the experimental work carried out on a variety of new metals and alloys.

A critical examination of the metals at present in use for the food industry (1) shows that two main groups are distinguishable. The first group consists of silver, copper, tin, nickel and the alloys, brass, bronze, phosphor bronze and nickel-silver. These metals do

not readily dissolve in acids with the evolution of hydrogen. An important point established concerning the action of organic acids on this series of metals is that such attack is only appreciable when air, oxygen and oxidising substances are present. For example, Bryan quotes the case of copper pans which are not attacked by boiling fruit juices of high acidity on account of the removal of all air from the juice, whereas the same juices in the cold state would soon attack the metallic surface of the pan.

In the second group are the following : aluminium and its alloys, the stainless steels, and nickel-chromium alloys. The resistance of this group of materials to corrosive acids is due to the formation of a film of oxide, impervious and closely adhering to the surface of the metal. Whilst the stainless steels possess an exceedingly resistant surface rendering them practically unaffected by prolonged contact with cider, they are difficult to work and the consequent high cost of apparatus militates against their more widespread use in the cider industry at the present time.

The general characteristics of the various metals which are used, or have been suggested for use with cider will be briefly enumerated.

Silver.

This "noble" metal is quite unattacked by cider. It is of great use for plating intricate apparatus which is in difficultly accessible positions, where constant examination or removal is not possible. The valve mechanisms inside the barrel of the carbonating machines used for the artificial aeration of cider are usually silvered. The layer of metal, if efficiently plated on the underlying copper or other metal, is very resistant to the action of cider, and short lengths of pipe for use in positions where permanence is important, can with advantage consist of silver or silvered tubes.

Copper.

Surfaces of this metal are definitely attacked by ciders, the latter in extreme cases becoming green in colour. Copper contamination leads to a pronounced taint, a very small amount of metal accounting for the spoilage of much cider.

Lead.

The action of cider on lead is of importance, the metal being quickly attacked and the surface destroyed. No formation of a resistant layer occurs ; the lead is probably dissolved in the form of bicarbonate $\text{Pb}(\text{HCO}_3)_2$, which adheres loosely to the metallic

surface, and afterwards is detached when the disintegration of the metal reaches a certain point. A lead tube inserted in a closed cylinder of cider was actually dissolved away to the extent of 20 per cent. of its original weight during a period of three months.

Lead may also gain access to cider by means of the glaze used in earthenware jars, and care must be exercised in the use of this form of vessel to determine whether the glaze is of the lead type.

Lead is a cumulative poison, and the lead poisoning of bygone days due to the drinking of cider received sufficient notoriety to become known as "Devonshire colic."

Iron.

Iron is a normal constituent of the ash of cider apples but the quantity is very small. Contamination with iron is one of the most difficult to avoid and dissolved iron salts quickly render a cider displeasing both to the palate and to the eye. Darkening due to iron is especially prevalent with bittersweet ciders on account of the formation of iron-tannin compounds. This disorder is usually prevented by maintaining an acidity of 0.5 per cent. malic acid.

Aluminium.

Some divergence of opinion has long existed on the matter of the advisability of using aluminium for cider. Workers have obtained contradictory results, which may possibly be explained by the fact that the resistance of aluminium to organic acids is an inverse function of the quantity of metallic and non-metallic impurities present. To ensure that these small proportions of extraneous elements are always present in exactly similar quantities is a matter of some technical difficulty, and it is probable that many samples of aluminium guaranteed 98-99 per cent. pure will vary in their resistance to organic acid corrosion. Aluminium has found favour in some manufacturing circles on account of its innocuous character, even when present in foodstuffs in a soluble condition in small quantities, whilst it is useful where interference with the natural colouring of the food product constitutes a disadvantage. Warcollier (2) has produced data showing that aluminium is definitely attacked by fresh apple juice and by cider. The presence of sulphur dioxide in solution causes increased attack on the metal. In all the tests the action of cider was more potent than in the case of unfermented juices; an explanation of this difference has been advanced by Durham (3), who points out that the presence of lactic acid in the fermented cider would account for the attack on the aluminium. In fact, a test using pure and "highly recommended"

aluminium immersed in dilute lactic acid, showed a definite and gradual solution of the metal.

Zinc.

This metal resembles lead in its reaction to cider and should be avoided in any form of apparatus.

Tin.

Present day practice in cider-making involves the use of a great deal of tinned-copper utensils and machinery, for it has been found to be the most satisfactory type of metal on account of the slower solution and the cheapness of this material in comparison with other metals. The method of plating the tin on to the copper is of paramount importance, and, as in other processes, it has been found that "dipping" is more satisfactory, affording as it does a more coherent, regular, continuous layer than the electrolytic method. Mantell (4) has shown that corrosion of tin by foodstuffs is due to one or all of the following causes :—

- (a) Discolouration due to sulphides (dependent on a restricted supply of oxygen).
- (b) Perforation by electrolytic action.
- (c) "Etching," due to actual solution of tin.

From observations on the surface of filters which have been in constant contact with cider, it seems that the greater part of the action is due to the last two of the above causes. Definite perforation can be observed, whilst the "etching" effect, giving rise to the characteristic fan-like appearance of the surface, is often encountered. An interesting observation in the literature is to the effect that sulphites may act as accelerators of the chemical solution of metallic tin. No definite information is available concerning the application of this statement to cider, but the matter is being tested at this station, in view of the use of sulphur dioxide for the preservation of cider in a sweet condition.

It is generally accepted that the plating of copper must be renewed at the first sign of any considerable appearance of copper and a filter being constantly used is likely to need replating after two or three seasons. It is important to keep the apparatus under careful scrutiny, for perforations are likely to cause electrical action between the surfaces of the tin and copper, thus giving an enhanced rate of solution of both these metals.

Quite recently tin-lined lead tubes have been introduced for conveyance of corrosive liquids. Preliminary tests have indicated that this type of tubing may be of use for cider. The lining is

composed of high-grade block tin (which is much superior to "washed" tin) annealed to the surface of the outer lead pipe (to give rigidity) by a special process; ingenious methods of forming T-pieces, and other necessary divergencies from straight pipe lines are adopted. This form of tube is at present undergoing further tests.

The toxic effect on the human system of foodstuff contaminated with metallic salts is difficult to summarise in a satisfactory manner. Medical Officers of Health, Public Analysts and Research Workers in Biochemistry hold strong views which are often the antithesis of each other. It has been observed in an exhaustive search of the food journals and analytical and legal literature, that many cases of supposed "metallic poisoning" of foods have been shown to have resulted from bacterial poisoning, and whilst in many cases the machines used to prepare the products have been regarded with suspicion, the true source of trouble was totally unconnected with the production plant.

Copper is much less toxic than lead. The former metal acts as an internal irritant and being a cumulative poison, sufficient cider would have to be taken regularly for the copper content of the system to rise to a value sufficiently high to cause sickness. Since copper has been shown to be a normal constituent of tomatoes, cocoa, peas, wheat, lobsters and oysters, it would seem safe to conclude that the small quantities normally dissolved in cider will be quite innocuous to the human system.

Tin contamination has been the subject of a great deal of research on account of the importance of the modern can for the canning industry. As a result of their investigations, Buchanan and Schryver (5) consider that 2 grains of tin per pound of foodstuff are liable to produce irritant action. It is certain that cider which passes through an ordinary well-conditioned tinned-copper filter will not contain this quantity of metal.

It is difficult to glean much definite information as to the toxicity of minute amounts of metals such as aluminium, nickel and chromium. In the case of the last two metals, it is very probable that they have a quite negligible effect in this respect.

From the above considerations, it is possible to say that there is little fear of any toxic effect occurring from the presence of metals through the drinking of cider, if lead and copper are absent, and thoroughly well tinned filters, etc., are used during manufacture.

In recent years, makers of ferrous and non-ferrous metals, and of alloys have turned their attention to the provision of materials

which could be satisfactorily used in a variety of food processes in view of the more stringent regulations governing the sale of these products. Cider-making plant and storage vessels have attracted considerable attention, and many specialised materials, quite satisfactory for use with other products, have been tested with varying results. A number of such metals and alloys have been investigated at Long Ashton and, in the present report, an account is given of some of the results obtained and their significance to the cider industry is discussed.

EXPERIMENTAL.

The testing of metals for the investigation of their resistance to cider has largely followed the usual immersion tests adopted by manufacturers for the determination of corrosion-resistance constants for their products.

In the series of experiments to be considered in this section of the report, the procedure adopted was as follows: the metal strips usually about 10 cm. x 1 cm. x 3 mm., were carefully washed with distilled water to remove any loose adhering material, heated gently in a flame, and weighed after cooling in a desiccator. Each strip was then suspended in the appropriate test solution (550cc.) in such a way that approximately half an inch of the strip extended above the solution. The bottles were tightly corked and placed in a cool place; if they were allowed to remain perfectly still, it was possible to obtain a clear division on the strip between metal that had been immersed in the test solution, and material above the level of the liquid. This facilitated the microscopic examination of the strips after the test period had ended, and enabled both types of surface to be viewed together. The test period was usually two months, although in some cases metals have been exposed to the action of ciders for six and twelve month periods. At the conclusion of a test, the metal strips were removed from the bottles and their surface condition examined. Any loose deposit was gently removed by lightly rubbing with the finger, the strip washed until quite clean, dried, and examined microscopically for signs of action of the fruit acids and other corrosive compounds. (In most of the samples examined, the corrosion has been slight and there has been no evident signs of it under the microscope).

The metal strips were then gently heated as before, cooled and re-weighed, and the loss in weight determined. No sharp dividing line can be laid down on a loss of weight basis by the above method to distinguish between metals which can be regarded as suitable or

unsuitable for cider machinery, but the arbitrary assumption, based on considerable experience, is made that materials which lose, in a two month period, more than 2 milligrams per 10 grams weight of metal, are unsatisfactory for general cider work.

The ciders and other test solutions were also examined for colour and flavour, the latter test usually being effected by several persons in view of the importance of the data thereby obtained. In some tests, the ciders were evaporated to dryness and ashed, and the ash, after solution in very pure hydrochloric acid, was examined by the usual qualitative wet tests for the metals likely to be present. The interpretation of these latter data presents some difficulty on account of the very small amounts of metals present, and recently such tests have been replaced by delicate qualitative and quantitative determinations.

Whilst the procedure is in some respects empirical, it does give in certain cases useful information concerning the resistance of metals to cider. But it is obvious that if a metal were being examined, for example, as to its suitability for pipes to convey cider, a truer insight into the corrosion effects to be expected would be obtained if the tests were conducted in such a way that the cider was continually passed through a tube of the material. The same remark applies to metals designed for filters, and especially for fast moving pieces of apparatus such as the centrifuge, where a jet of cider is forced up against the metallic surface. Apart from some elaborate form of apparatus, it does not seem possible to reproduce the normal wear and tear of cider machinery in the laboratory, but attempts are being made to devise a method more closely resembling commercial processes.

Preliminary Experiments.

The first experiments carried out at Long Ashton dealt with a series of single metals, and one alloy (gunmetal). The ciders used possessed the following analyses:—

Sharp cider : 0.7 per cent. malic acid and 0.2 per cent. tannin.

Bittersweet cider: 0.25 per cent. malic acid and 0.49 per cent. tannin.

Acetified cider: 0.36 per cent. malic acid, 0.18 per cent. tannin, 0.3 per cent. acetic acid.

The results are tabulated in Table I.

TABLE I.

ACTION OF CIDER ON VARIOUS METALS.

Metal.	Type of Cider.	Colour of Cider.	Flavour of Cider.	Visible Action of Cider on Metal.	Metal Found.
Copper.	Sharp	Unaltered	Strongly metallic	Nil	Trace
	Bittersweet Acetified	„ A little darker	„ „	„ „	Nil Trace
Tin.	Sharp	Paler	Unaltered	Nil	Nil
	Bittersweet Acetified	Unaltered Paler	„ „	Slight Nil	Trace Nil
Aluminium.	Sharp	Unaltered	Unaltered	Nil	Nil
	Bittersweet Acetified	„ „	„ „	„ „	„ „
Lead.	Sharp	Unaltered	Very Slightly metallic	Slight	Trace
	Bittersweet Acetified	Darker Unaltered	„ „	„ „	„ „
Iron.	Sharp	Black	Very strongly metallic	Very considerable	Large amounts
	Bittersweet Acetified	„ Dark brown	„ „	„ „	„ „
Zinc.	Sharp	Very dark	Strongly metallic	Very considerable	Large amounts
	Bittersweet Acetified	Dark „	„ „	„ „	Trace Large amounts
Silver.	Sharp	Unaltered	Unaltered	Nil	Nil
	Bittersweet Acetified	„ „	„ „	„ „	„ „
Nickel.	Sharp	Unaltered	Unaltered	Nil	Nil
	Bittersweet Acetified	A little darker. Unaltered	„ „	„ „	„ „
Gunmetal.	Sharp	Unaltered	Metallic	Nil	Trace
	Bittersweet Acetified	„ „	„ „	„ „	„ „

Experiments with Alloys.

The modern development of alloys has shown the considerable improvement in resistance to corrosion which can be obtained by

the admixture of a variety of suitable metals, in some cases by the addition of very small proportions of certain metals to the main metal. The results which follow relate to the resistance of a number of alloys, mostly of recent introduction, and many of which show excellent corrosion resisting qualities.

Austenitic Cast Iron.

Valuable properties can be conferred on steels by the use of large proportions of alloy additions such as nickel, chromium and manganese. The increased resistance to corrosion and heat are due to the fact that the steels are in the austenitic state. Similar properties can be induced in cast irons, and types of these latter alloys have been tested for use in contact with cider. Two series of metals were received from the manufacturers, the alloy compositions being: A. = 25 per cent. nickel, 5 per cent. chromium. B. = 30 per cent. nickel, 8 per cent. chromium.

The strips were tested for three months, and examined for pitting, etc., as mentioned above in the scheme adopted for single metals.

The solutions used and details of the tests are tabulated below. The synthetic solution appearing in this and other tests consisted of a solution in tap water of malic acid and tannic acid in the given proportions.

TABLE IIa. TEST SOLUTIONS.

Number of Test.	Solution.	Acidity (as Malic Acid) %	Tannin %
1	Very sharp cider	1.10	0.11
2	Medium sharp cider	0.52	0.12
3	Bittersweet cider	0.31	0.36
4	Synthetic solution	0.5	0.2
5	0.5 per cent. sulphur dioxide ..	—	—
6	Cider vinegar	5.0*	—

* Acidity as Acetic Acid.

It would appear from these tests that the materials represented by Samples A and B are satisfactory in their resistance to ciders of widely differing compositions. A point of considerable interest is raised by the low resistance of the metals to the synthetic acid + tannin solution. This is difficult to understand, but a possible clue may be found by considering the various gaseous contents of the test solutions. The ciders were all charged with carbon dioxide (from natural fermentation in bottle after filtration) which would exclude the possibility of much air, and consequently oxygen, being present. On the other hand, the synthetic solution was prepared

TABLE IIb.

ACTION OF CIDER AND OTHER LIQUIDS ON AUSTENITIC CAST IRONS.

No. of Test.	Cider or Solution used.	Weight of bar before test. grms.	Weight of bar after test. grms.	Loss in Weight. grms.	Influence of metal on flavour of cider.	Influence of test solution on metal.	Foreign metals found in ash of ciders.
SAMPLE A.							
1	Very sharp cider ..	33.1411	33.1410	0.0001	Nil	Very slightly darkened	Cu, Fe (trace).
2	Medium sharp cider ..	29.2744	29.2739	0.0005	"	"	Cu, Fe (trace).
3	Bittersweet cider ..	31.3082	31.3082	Nil	"	"	Cu, Fe (trace).
4	Synthetic solution ..	31.9640	31.9380	0.0260	—	Surface roughened	—
5	0.5% SO ₂ solution ..	31.7858	31.4840	0.3018	—	Surface deeply pitted	—
6	Cider vinegar ..	29.9822	29.9660	0.0162	—	Metal darkened	—
SAMPLE B.							
1	Very sharp cider ..	30.0376	30.0374	0.0002	Nil	Slightly darkened	Slight trace of Cu, Fe.
2	Medium sharp cider ..	30.7994	30.7990	0.0004	"	"	"
3	Bittersweet cider ..	26.1902	26.1900	0.0002	"	"	"
4	Synthetic solution ..	30.8611	30.8280	0.0331	—	Surface badly pitted	—
5	0.5% SO ₂ solution ..	29.9234	29.3810	0.5424	—	Surface completely destroyed	—
6	Cider vinegar ..	28.8442	28.8369	0.0073	—	Considerable blackening	—

by dissolving the required amounts of malic and tannic acids in tap water and suspending the metal in a bottle filled with this solution. It is evident that the latter solution will contain some dissolved air and oxygen, and it may well be that this is the factor accelerating the actual attack on the metal. This point is now being considered in connection with the general scheme for testing metals in cider.

The sulphur dioxide solution was much weaker than the usual 2 per cent. solution used for sterilising all forms of surfaces which come into contact with cider, but owing to the nature of the sterilising treatment (in which contact with the metal is limited to a few minutes) no serious damage is likely to occur when austenitic cast irons are concerned.

The ciders, in all three cases, were slightly darkened by the strips, but in no case was the effect of sufficient magnitude to be detrimental to the use of this type of metal. No extraneous flavour which could be attributed to dissolved metal could be detected.

The traces of copper discovered in the ash of the various ciders may be attributed to impurities present in the alloy.†

Chrome-Nickel Steel.

Chromium and nickel are generally associated together in the manufacture of resistant steel alloys; as the percentages employed are usually 18 per cent. nickel and 8 per cent. chromium, such alloys have become known as 18-8 steels. Samples of a chrome-nickel alloy were tested in the usual way, the solutions used and results obtained being as follows:—

TABLE IIIA. TEST SOLUTIONS.

Number of Test	Solution.	Acidity (as Malic Acid) %	Tannin %
1	Sharp cider (Frederick)	0.94	0.13
2	Sweet cider (Sweet Alford) ..	0.21	0.17
3	Bittersweet cider (Belle Norman)	0.30	0.30
4	Cider vinegar	5.0*	—
5	0.5 per cent. sulphur dioxide ..	—	—
6	Synthetic solution	0.5	0.2

* Acidity as Acetic Acid.

† The matter of copper content was discussed with the makers, who eventually discovered that Metal "B" contained a small percentage of copper which had probably arisen from the use of a crucible previously used for some copper-containing alloy. The latest forms of austenitic cast-irons do not contain copper.

TABLE IIIB.
ACTION OF CIDER AND OTHER LIQUIDS ON CHROME-NICKEL STEEL.

No. of Test.	Cider or Solution used.	Weight of bar before test. grms.	Weight of bar after test. grms.	Loss in Weight. grms.	Influence of metal on flavour of cider.	Influence of test solutions on metal.	Foreign metal found in ash of ciders.
1	Sharp cider ..	13.4658	13.4658	Nil	Nil	Nil	Nil
2	Sweet cider ..	12.1648	12.1648	"	"	"	"
3	Bittersweet cider ..	10.9357	10.9348	0.0009	"	Metal slightly blackened	"
4	Cider vinegar ..	11.4271	11.4235	0.0036	—	Metal blackened	—
5	0.5% sulphur dioxide	13.0700	13.0379	0.0321	—	Metal badly attacked	—
6	Synthetic solution ..	11.9708	11.9690	0.0018	—	Metal slightly blackened	—

In the cider samples, the bittersweet type was unique in affecting the metal in any way. Even in this case, the corrosion was slight, and only a trace of iron was found in the ash of the cider.

The synthetic solution, whilst affecting the chrome-nickel to a greater degree than did the bittersweet cider, did not cause corrosion to the same extent as to the austenitic cast-iron sample.

From these results, chrome-nickel steel appears to be a useful addition to the list of cider resistant materials.

Corrosion Resisting Steel.

A similar series of tests were carried out on two different samples of corrosion resistant steel.

The relevant data are tabulated below :—

TABLE IVA. TEST SOLUTIONS.

No. of Test.	Solution.	Acidity (as per % Malic Acid).	Tannin %
1	Kingston Black cider	0.68	0.23
2	Second quality cider	0.52	0.15
3	Sharp cider	1.11	0.12
4	Bittersweet cider	0.26	0.36
5	Sweet cider	0.26	0.15
6	Sweet cider + sulphur dioxide* ..	0.26	0.15
7	Cider vinegar	5.0†	—

* The legal maximum dose of 14 grains per gallon (200 parts per million) was used.

† Acidity as Acetic Acid.

TABLE IVb. ACTION OF CIDER ON CORROSION RESISTING STEELS.

No. of Experiment.	Weight of bar before test. grms.	Weight of bar after test. grms.	Loss in Weight. grms.	Influence of metal on flavour of cider.	Influence of test solution on condition of metal.
SAMPLE I.					
1	21.9293	21.9290	0.0003	Nil	Nil
2	25.5365	25.5365	Nil	"	"
3	24.7998	24.7995	0.0003	"	"
4	24.3369	24.3369	Nil	"	"
5	21.6741	21.6733	0.0008	"	"
6	22.9066	22.9066	Nil	"	"
7	23.6134	23.6130	0.0004	—	"
SAMPLE IV.					
1	23.1192	23.1187	0.0005	Nil	Nil
2	23.8183	23.8180	0.0003	"	"
3	24.2923	24.2923	Nil	"	"
4	23.1982	23.1980	0.0002	"	"
5	23.2480	23.2469	0.0011	"	"
6	23.9725	23.9705	0.0020	"	"
7	21.9748	21.9748	Nil	—	"

The tests definitely reveal the resistance of the two metals to cider during contact for two months. It will be noticed that anomalous results were obtained with the use of sweet cider preserved with sulphur dioxide. In the case of No. IV steel, the corrosion with sweet cider + sulphur dioxide was twice as great as that with the cider alone. In No. 1 steel, the action was in the reverse order, no corrosion having occurred with the "preserved" cider, whilst the sweet cider alone had effected a slight solution of metal.

Chrome-Nickel Steel.

This type of steel is of the high chromium-nickel type, the percentages being: chromium 15-18 per cent., nickel 11-18 per cent.

The steel is recommended by the makers for almost every corrosive acid with the exception of sulphuric and hydrochloric acids.

Similar tests effected on strips of this metal are tabulated below:—

TABLE VA.
TEST SOLUTIONS.

No. of Test.	Type of Cider.	Acidity (as Malic Acid) %	Tannin %
1	Very sharp	1.21	0.11
2	Medium sharp	0.80	0.13
3	Sweet	0.26	0.15
4	Bittersweet	0.38	0.38
5	Acetic	0.94*	0.18

* Total acidity 0.94%, Acetic Acid 0.52%.

TABLE VB.
ACTION OF CIDERS ON CHROME-NICKEL STEEL.

No. of Experiment.	Weight of bar before test. grms.	Weight of bar after test. grms.	Loss in Weight. grms.	Influence of metal on flavour of cider.	Influence of cider on condition of metal.
1	9.8364	9.8354	0.0010	Nil	Nil
2	9.7212	9.7200	0.0012	"	"
3	14.1221	14.1220	0.0001	"	"
4	11.4694	11.4686	0.0008	"	"
5	9.6401	9.6386	0.0015	"	"

The resistance of this steel to cider is shown by the very small corrosion effects caused by a variety of ciders. It is of interest to note that the highly acid and astringent ciders have caused much greater corrosion compared with the low acid—low tannin cider (No. 3), whilst the acetified cider has contributed the highest degree of metallic solution.

A further test was made on this metal during an experiment on the production of a non-alcoholic apple juice by retaining the juice in a pressure vessel of tubing of 4 in. diameter. The juice, containing 0.72 per cent. malic acid, and 0.17 per cent. tannin, was allowed to remain in the pressure vessel for several months, at the end of which period the cider and metal were found to be unaffected by the prolonged contact.

Acid Resistance Bronze.

This alloy contained 89.5 per cent. copper, 10 per cent. pure tin, 0.5 per cent. phosphorus.

Round rods of this metal were available for testing with the same solutions as for the previous test on chrome-nickel, with the exception of the synthetic solution. The detailed analysis of the test follows in Table VI.

TABLE VI.
ACTION OF CIDER ON ACID-RESISTING BRONZE.

Test No.	Test Solution.	Weight of bar before test. grms.	Weight of bar after test. grms.	Loss in Weight. grms.	Action of metal on flavour of cider.	Action of cider on metal.
1	Medium sharp cider ..	110.8770	110.8686	0.0084	Nil	Nil
2	Very sharp cider ..	112.4348	112.4039	0.0309	Slightly metallic	„
3	Bittersweet cider ..	111.9344	111.9300	0.0044	„	—
4	Cider vinegar ..	111.9065	111.9061	0.0004	„	Slightly blackened
5	0.5% SO ₂ ..	111.7991	111.7930	0.0061	—	„
*6	Cider vinegar ..	111.7948	111.7896	0.0052	—	Nil

* Tinned bar.

The quantities of metal dissolved were not appreciable, but these ciders possessed a very slight metallic taste. The heavily tinned bronze bar proved to be fairly resistant to the action of acetic acid in a cider vinegar medium.

Bronze.

Two samples of bronze were examined by the same procedure, giving the undermentioned results :—

TABLE VII.
ACTION OF CIDER ON BRONZE.

Metal.	Cider Used.	Weight of bar before test. grms.	Weight of bar after test. grms.	Loss in Weight. grms.	Influence of metal on flavour of cider.	Influence of cider on metal.
Bronze No. 10 (Copper 95%, tin 5%).	Very sharp ..	26.0703	26.0703	Nil	Nil	Nil
No. 10	Medium sharp ..	25.6074	25.6060	0.0014	"	"
No. 10	Sweet	25.3670	25.3654	0.0016	"	"
No. 10	Screw stopper blend	26.0075	26.0068	0.0007	"	"
Bronze No. 12 (Copper 96½%, tin 3½%).	Very sharp ..	26.2689	26.2693	—0.0004	"	"
No. 12	Medium sharp ..	25.1422	25.1412	0.0010	Slightly metallic	"
No. 12	Sweet	27.1638	27.1620	0.0018	"	"
No. 12	Screw stopper blend	26.0918	26.0915	0.0030	"	"

The two alloys differed but slightly in their resistance to cider, both being quite satisfactory.

Cupro-Nickel.

A sample of this alloy was tested, and afforded the following results :—

TABLE VIII.
ACTION OF CIDER ON CUPRO-NICKEL.

No. of Test.	Type of Cider.	Weight of bar before test. grms.	Weight of bar after test. grms.	Loss in Weight. grms.	Influence of metal on flavour of cider.	Influence of cider on metal.
1	Very sharp ..	25.1489	25.1486	0.0003	Nil	Nil
2	Medium sharp ..	25.0100	25.0080	0.0020	Slightly metallic	"
3	Sweet	25.6603	25.6606	0.0016	Nil	"
4	Screw stopper blend	26.0101	26.0100	0.0001	"	"

From these tests, it will be seen that the corrosion taking place is very slight. Ordinary qualitative tests showed the presence of only very small amounts of copper or nickel in the ash of the cider.

Aluminium.

The early series of experiments on metals and alloys (Table I), includes tests carried out on aluminium. It is unfortunate that the exact composition of the metal used in those tests is not available, for it is apparent that the metal was completely resistant to attack by ciders.

Since that time, two further trials have been carried out on special forms of aluminium.

In the first case, duralumin, an alloy of aluminium containing 4 per cent. copper and 0.5 per cent. each of manganese and magnesium, and possessing an extraordinarily high tensile strength, was found to be totally unsuitable for cider work. Large quantities of aluminium were found in the ash of the ciders, and whilst the flavour was not greatly affected, the trial showed that duralumin was not satisfactory for use with cider.

The second aluminium material was produced by the electrolytic deposition of a supposedly impermeable layer of oxidised material on the surface of 98-99 per cent. aluminium. The material was examined in some detail, the following Tables giving the data from the tests.

Treated and untreated strips of metal (98-99 per cent. pure) were immersed in similar test solutions. In Tests No. 6, 7, 8 and 9, strips were either suspended in or laid on the bottom of glass gallon jars, filled with a nutrient medium fermenting with either cider yeast or brewer's yeast. The deposit of yeast was such that the strips on the bottom of the jar became completely embedded.

TABLE IXA.
TEST SOLUTIONS.

No. of Test.	Solution.	Acidity (as Malic Acid) %	Tannin %
1	Sharp cider	1.0	0.10
2	Medium sharp cider	0.77	0.10
3	Bittersweet cider	0.25	0.26
4	Medium quality cider	0.53	0.17
5	Cider vinegar	5.0*	—
6	Cider yeast (embedded)	—	—
7	Cider yeast (suspended)	—	—
8	Brewer's yeast (embedded)	—	—
9	Brewer's yeast (suspended)	—	—

* Acidity as Acetic Acid.

TABLE IXp.
ACTION OF CIDER AND BREWER'S AND CIDER YEASTS ON TREATED AND UNTREATED ALUMINIUM.

No. of Experiment	Solution used.	Weight of bar before test. grms.	Weight of bar after test. grms.	Loss in Weight. grms.	Influence of metal on flavour of cider.	Influence of cider, etc., on condition of metal.
UNTREATED						
	METAL.					
1	Sharp cider	10.8104	10.7963	0.0141	Very slight	Bright surface dulled
2	Medium cider	10.6816	10.6672	0.0144	"	"
3	Sweet cider	10.8244	10.8128	0.0116	Nil	"
4	Medium quality cider ..	10.8837	10.8700	0.0137	"	"
5	Cider vinegar	10.8355	10.8240	0.0115	"	"
6	Cider yeast (embedded) ..	10.7842	10.7800	0.0042	—	"
7	Cider yeast (suspended) ..	10.7700	10.7622	0.0078	—	"
8	Brewer's yeast (embedded) ..	10.7548	10.7492	0.0056	—	"
9	Brewer's yeast (suspended)	10.7394	10.7330	0.0064	—	"
TREATED						
	METAL.					
1	Sharp cider	10.8990	10.5704	0.3286	Metallic taste	Surface yellow and rough.
2	Medium sharp cider	10.8857	10.5810	0.3047	"	"
3	Sweet cider	10.8248	10.6100	0.2148	"	Surface deep orange-brown
4	Medium quality cider (for sale)	10.8749	10.8220	0.0529	"	"
5	Cider vinegar	10.8512	10.5152	0.3360	"	Resistant layer completely removed
6	Cider yeast (embedded) ..	10.8362	10.8000	0.0362	—	Resistant layer irregularly attacked
7	Cider yeast (suspended) ..	10.8670	10.7920	0.0750	—	"
8	Brewer's yeast (embedded) ..	10.8604	10.8360	0.0244	—	"
9	Brewer's yeast (suspended) ..	10.8986	10.8972	0.0014	—	"

The untreated strips of metal were observed before testing to be scratched in one or two places, whilst the treated bars were conspicuous for a series of irregular "cracks" across their whole surface. It may well be that this accounts for the very considerable losses occasioned during the tests ; in both treated and untreated samples the corrosion was such as to discountenance the use of the metal in either form.

The appearance of the metals after immersion in the various test solutions was of interest. The "cracks" were still visible under a microscope, but their sharp contours were greatly diminished, whilst the surface of the treated bars was seen to be broken into a series of irregular striations, the whole being coloured to quite an obvious degree. Much literature has appeared concerning the methods of plating various metallic surfaces, and as was the case of tin, it is probable that the surface of oxidised aluminium will be more satisfactory when a more efficient method of treatment is available.

Estimation of Copper and Tin in Filtered Ciders.

In view of the fact that the tinned-copper filters used for clarification of cider have been suspected of contributing a metallic flavour to the filtrate, especially after the tin layer has commenced to corrode, attempts were made to estimate the tin and copper content of ciders passed through the smaller of the two filters used for bulk treatment in the ciderhouse. As copper might perhaps be a constituent of the apple juice, control samples were taken before passage of the cider through the filter, and the two metals under consideration estimated in a similar manner. Owing to the very small percentages of either metal expected to be in solution, a special procedure was adopted, which is briefly outlined here. 200cc. of cider, collected by rubber siphon from the cask of cider to be filtered, and from the nearest tap to the filter exit, were evaporated to a syrup, and incinerated in a gold dish. The ash was taken up in hydrochloric acid, and bulked to 100 cc. Aliquot portions were taken for the colorimetric estimations of copper and tin. For the former, the aliquot was rendered strongly alkaline with ammonia and the flocculent precipitate (largely iron) so formed was removed by filtration. The clear filtrate was collected in a 50 cc. Nessler tube, and 10 cc. of Sodium diethyl-dithiocarbamate solution added.(5) A yellow colouration is formed with copper, and the depth of colour may be matched against that produced in a series of standard copper solutions. The sensitivity is such that 1 part of copper in 100 million parts of solution may be detected.

The tin estimation was more complicated.(6) It was decided to utilise Schryver's tin test as follows: an aliquot of the ash solution was made strongly acidic with hydrochloric acid and received in a large 1 in. diameter boiling tube closed with a cork, fitted with two glass tubes one of which was arranged to be 1 in. above the solution. Carbon dioxide was passed through the tube, and the contents boiled. 0.75 gram of pure zinc was quickly added, and when solution was complete, all the tin being in the stannous condition, 2 cc. of a solution of α dinitro-diphenylamine sulphoxide in $\frac{N}{10}$ caustic soda were added. The contents of the test tube were again boiled, and on cooling made up to 100 cc. The presence of tin is shewn by the production of a violet colour, which reaches maximum intensity with the addition of one drop of dilute ferric chloride solution. Although the test is extremely delicate, the ciders tested, whether filtered or not, all contained insufficient tin to give a coloration.

The data for copper obtained by this means are tabulated in Table X.

TABLE X.
COPPER IN FILTERED AND UNFILTERED CIDERS.

Cider used in Test.	Acidity %	Tannin %	Copper in unfiltered cider in parts per million.	Copper in filtered cider in parts per million.
Knotted Kernel	0.30	0.40	0.2	0.4
Layne's Colonels	0.75	0.22	0.2	0.3
Kingston Black	0.74	0.23	0.2	0.3

The filter used was in its third season since replating with tin, and was chosen for the express purpose of giving results reasonably comparable to filters in commercial cider factories. The tin had been completely removed in one or two places, revealing the underlying copper. Especially near the top of the filter some weaknesses in the tin plating were observed, and in the normal course of cider-house routine, the filter will be replated at the first opportunity. But even in this condition, the filter does not appear to lose much tin or copper to the cider.

The above figures tend to show that with cider moving across a sheet of tinned copper, even when some underlying metal is accessible to the cider, very little danger is possible from solution by the cider of either metal. Trouble will arise, however, when the cider is left in contact with the filter for a period of hours, and on no account should cider be allowed to remain in the filter overnight.

A similar test was carried out on cider passing through the centrifuge. A very faint trace of tin was found by Schryver's test, whilst the issuing cider contained 0.4 parts per million of copper. The bowl of the centrifuge is composed of monel metal, which has shewn itself to be quite satisfactory in this machine.

SUMMARY.

1. The importance of preventing contact of cider with metallic surfaces is shown.
2. It is indicated that the chief source of trouble arising from metallic contamination of ciders is their characteristic metallic taste.
3. Several alloys have been shown to possess satisfactory resistance to cider, under the conditions of the tests.
4. Sharp, Bittersweet, and Kingston Black ciders have been shown to dissolve only exceedingly minute quantities of copper during filtration through a tinned-copper pulp filter.

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THE USE OF COMMERCIAL PECTINS IN HOME-MADE JAMS.

By MARGARET L. ADAMS.

Certain fruits are naturally deficient in pectin, as for example, rhubarb, apricots, strawberries, cherries and pineapples. In such cases jams or jellies with a good set can be readily produced by the addition of pectin prepared from sources rich in this constituent, and in view of this, methods have been devised for the extraction and preparation of tasteless and colourless pectin from fruits such as apples and citrus fruits, in which it occurs abundantly. The commercial jam-manufacturer has used such pectins for years, but it is only within very recent times that pectin has been sold in sufficiently small bulk to be purchased for use in the home.

The housewife, particularly in rural areas, who sends her jams and jellies to Produce Exhibitions, etc., realises that a well-set jam, from the points of view of transport and keeping quality, is much more satisfactory than a "runny" jam. She has previously tried to remedy the pectin deficiency of strawberries and cherries by adding gooseberry, red currant or lemon juice during the process of making, thus really adopting the same principle as the commercial manufacturer. There was this difference, however, that whereas the commercial manufacturer used pectin of known strength, the procedure of the housewife was empirical as regards the amount of pectin added. Moreover, the better brands of commercial pectins are entirely flavourless, but when gooseberry or red currant juice is added to strawberry jam, the flavour of the strawberry must of necessity be affected. Although the housewife was thus using the same principle as the jam manufacturer, she did not realise this, and when pectin was first available to her on the market she was loathe to use it, feeling probably that in doing so she would be adding some undesirable chemical to the jam. However, as the result of very intensive advertising in Women's Magazines, etc., on the part of pectin manufacturers, combined with the gradual realisation by the housewife that commercial pectin is a quite innocuous fruit extract, an increasing number of housewives are using it.

In view of the possible value of commercial pectins in home

jam making and of the lack of data relating to the use of the materials for this purpose, experiments were carried out during the fruit seasons of 1932, 1933. The main objects of these were as follows :—

1. To discover what advantages, if any, are to be gained by using commercial pectin in home-made jams.
2. To determine the types and brands which yield satisfactory results.
3. To test the recipes and methods recommended by the manufacturers of various brands.

Experimental.

The conditions under which the tests were carried out approximated as far as possible to those in an average household. In 1932, the trials were confined to strawberries from which fruit 18 boilings of jam were made. The proportions used in the first tests were based on a recipe given by a pectin manufacturer, but as the results were not satisfactory, the proportions were altered. (Table I, Samples A, B and C.) In subsequent experiments, the amounts of jam from each boiling were comparable to those made in a small household, the average proportions being 2 lbs. fruit to 3 lbs. of sugar. In some samples the proportion of fruit was increased to $2\frac{1}{2}$ lbs., and in others the sugar was decreased to $2\frac{1}{2}$ lbs. (Table I, Samples G, H, I, J, K, M and O.) To certain samples small quantities of acid, such as tartaric acid and lemon juice, were added. Except in the first three tests (Table I, Samples A, B and C), the proportion of pectin was constant, *i.e.* 28 grms. (1 oz.) powdered pectin or 4 oz. liquid pectin. For purposes of comparison strawberry jam was made without the addition of commercial pectin, using (1) fruit and sugar only, (2) fruit, sugar and lemon juice, and (3) fruit, sugar and gooseberry juice. (Table I, Samples P, Q and R.)

In 1933, in addition to strawberry, cherry, raspberry, gooseberry, black currant and plum jams were made. The proportions of fruit, sugar and pectin were similar to those used in 1932. For the hard fruits, of course, the addition of water was necessary. Powdered pectin only was used, as the results of the tests in which liquid pectin was used in 1932 were not quite of the standard desired in all respects.

All the jams were made in a small aluminium jam pan and were heated on a gas stove on which the gas pressure varied considerably

TABLE I.
1932 EXPERIMENTS WITH STRAWBERRY JAMS.

Sample.	Weight of Fruit. lbs. ozs.	Weight of Sugar. lbs.	Weight of Pectin. ozs.	Addition of Acid.	Yield of Jam. lbs. ozs.	Time to Make. mins.	Colour and Flavour.	Set.	Keeping Quality.
A.	1 10	2	$\frac{2}{3}$ Powdered.	—	3 2	20	Colour good. Flavour very sweet.	Syrupy, too stiff.	Crystallised in 3 months.
B.	1 12	2	$\frac{2}{3}$ Powdered.	—	3 8	17	Colour good. Flavour very sweet.	Poor.	Mould in 3 months.
C.	1 12	2	$\frac{2}{3}$ Powdered.	Juice of $\frac{1}{2}$ lemon.	3 8	16	Colour very good. Flavour slightly sweet.	Rather uneven.	Slight mould in 6 months.
D.	2 —	3	1 Powdered.	—	4 8	18	Colour very good. Flavour too sweet.	Weak.	Crystallisation in 6 months.
E.	2 — (1lb. cut up)	3	1 Powdered.	—	4 8	20	Colour very good. Flavour sweet.	Good.	Slight crystallisation in 6 months.
F.	2 —	3	1 Powdered.	3.5 gr. Tartaric acid.	4 10	16	Colour very good. Flavour excellent.	Very good.	Good.
G.	2 8	3	1 Powdered.	—	5 1	18	Colour very good. Flavour very good.	Fair.	Mould in 6 months.
H.	2 8	3	1 Powdered.	2 gr. Tartaric acid.	5 3	16	Colour very good. Flavour slightly acid.	Moderately good.	Slight mould in 6 months.
I.	2 —	2 $\frac{1}{2}$	1 Powdered.	—	4 2	15	Colour very good. Flavour very good.	Good.	Good.
J.	2 — Berries crushed.	2 $\frac{1}{2}$	1 Powdered.	—	4 2	16	Colour very good. Flavour very good.	Very good.	Good.
K.	2 —	2 $\frac{1}{2}$	1 Powdered.	2 gr. Tartaric acid.	4 3	16	Colour very good. Flavour slightly acid.	Very good.	Good.
L.	2 —	3	4 Liquid A.	—	4 12	18	Fruit brown, jelly clear. Very poor and very sweet. Slight metallic taste.	Good.	Considerable mould within 3 months, crystallisation.
M.	2 —	3	4 Liquid A.	Juice of $\frac{1}{2}$ lemon.	4 12	17	As above, but flavour less sweet. Metallic taste.	Good.	As above. Slight crystallisation.
N.	2 8	3	4 Liquid A.	—	5 4	18	As above.	Fair.	Mould within 3 months.
O.	2 —	2 $\frac{1}{2}$	4 Liquid A.	—	4 3	18	Berries brown. Flavour fair and metallic.	Good.	Slight mould within 6 months.
P.	2 —	2	—	—	3 2	35	Poor colour. Flavour very cooked.	Poor.	Mould within 3 months.
Q.	2 —	2	—	Juice of 1 lemon.	3 2	30	Colour good. Flavour quite good.	Fair.	Mould within 6 months.
R.	2 —	2	—	$\frac{1}{2}$ pt. gooseberry juice.	3 6	25	Colour good, though berries rather brown. Flavour good.	Fair.	Slight mould within 6 months.

TABLE II.
1933 EXPERIMENTS WITH VARIOUS JAMS.

STRAWBERRY. A.	2 #lb. sliced.	3	1	—	4	10	16	Colour very good. Flavour a little sweet.	Very good.	Good. Slight crystallisation.
B.	2½ #lb. sliced.	3	1	—	5	2	17	Colour very good. Flavour very good.	Rather weak.	Slight mould in 6 months.
C.	2	2½	1	—	4	4	16	Colour very good. Flavour excellent.	Very good.	Good.
D.	2	2	—	½ pint gooseberry juice.	3	4	30	Poor colour. Flavour quite good.	Poor.	Poor.
E.	2 (covered with sugar overnight).	2	—	—	2	12	30	Colour poor. Flavour too sweet.	Syrupy.	Good.
F.	4	6	2	—	9	12	19	Colour good. Flavour a little sweet.	Good.	Good.
CHERRY. A.	2 (stoned).	3	1	—	4	9	18	Colour good. Flavour too sweet.	Good.	Good. Very slight crystallisation.
B.	2	2½	1	—	4	2	17	Colour good. Flavour good.	Very good.	Good.
RASPBERRY. A.	2	3	1	—	4	12	15	Colour good. Flavour good, a little too sweet.	Good.	Good. Very slight crystallisation.
B.	2	2½	1	—	4	3	15	Colour good. Flavour very good.	Very good.	Good.
C.	2	2½	—	—	4	—	20	Colour good. Flavour good.	Good.	Good.
D.	2	3	1	—	5	—	Fruit just heated to 170 F.	Colour excellent. Flavour excellent.	Very good.	Good, but slight crystallisation.
GOOSEBERRY. A.	2 + ½ pt. water.	3	1	—	5	4	20	Colour excellent. Flavour excellent.	Very good.	Good.
B.	2 + 1 pt. water.	2½	—	—	4	4	40	Colour rather brown. Flavour quite good.	Very good.	Good.
BLACKCURRANT. A.	2 + ½ pt. water.	3	1	—	5	4	20	Colour good. Flavour good. Skins a little hard.	Too stiff.	Good.
B.	2 + 1 pt. water.	3	1	—	5	12	20	As above. Skins soft.	Very good.	Good.
C.	2 + 1½ pt. water.	3	—	—	5	—	40	Colour good. Flavour more cooked. Skins soft	Very good.	Good.
D.	2 + 1½ pt. water.	3½	1	—	6	—	25	Colour good. Flavour good, a little sweet.	Good.	Good.
PLUM. A.	2 + ½ pt. water.	3	1	—	5	4	20	Very good.	Good, slightly stiff.	Good.
B.	2 + 1 pt. water.	3	1	—	5	10	20	Very good.	Very good.	Good.

according to how much gas was being used elsewhere in the building. When powdered pectin was used the fruit was heated until some juice was extracted, the powder sifted in carefully and then the fruit boiled rapidly for two minutes, when the sugar was added, stirred until it was dissolved and the jam boiled for 3 minutes. When liquid pectin was used, the fruit and sugar were heated and stirred together until the sugar was dissolved. The jam was brought to boiling point and boiled rapidly for 3 minutes, then the liquid pectin stirred in. The methods in both cases were based on instructions given by pectin manufacturers. The periods of time given in the tables are inclusive of the time at which cooking began and the time at which setting point was reached.

The finished jams were all poured into 1 lb. jars, and any jam at the end of each boiling which was less than 1 lb. was poured into a jar of known weight and then weighed, in order to obtain reasonably accurate figures regarding the yield of jam. Wax circles were placed on the surfaces of the jam in the jars and, when cold, the jars were sealed with covers made of compressed paper. On the following day 1 jar from every batch of jam was opened and the contents examined for colour, flavour and set. After periods of three and six months respectively, the jams were tested for keeping properties.

Discussion of Results.

When satisfactory proportions of fruit, sugar and powdered pectin were found, the resulting jams were very good. Those in which liquid pectin was used were less satisfactory as a whole. In the strawberry jam tests of 1932, the set and flavour of the jam were improved by the addition of small amounts of acid (Table I, Sample F), but in the 1933 tests with powdered pectin, the addition of acid was unnecessary as the acidity of the pectin was higher. Soft fruit jams, such as strawberry and cherry made with the addition of powdered pectin, were superior in every respect to jams made from fruit, sugar and lemon juice. The resulting jams from fruits rich in pectin, such as gooseberry, black currant and plum, to which powdered pectin was added, were excellent in quality and, although the setting quality was not noticeably superior to that of good jam made by the usual method, the flavour and yield were more satisfactory, due no doubt, to the shorter period of cooking.

Strawberry Jam. In the making of this jam, which is liable to present difficulties, there is certainly a strong case for using at least one type of commercial pectin. The jam made with added powdered

pectin was superior in colour, flavour and set to the average sample made with fruit and sugar only, or with fruit, sugar and gooseberry juice (c.f. strawberry jam 1932, Samples F and I, with P, Q and R). In addition to the above advantage, the jam was made with less labour, gave a better yield, and fuel and time were saved.

The same good results were not obtained when liquid pectin was used. Where this was employed the general appearance of the products was attractive, but they did not bear too close inspection. The chief disadvantages in connection with liquid pectin were threefold: (1) it transmitted a perceptible and slightly peculiar flavour to the jam, (2) it is sold in bottles or cans, and it was found that unless all the contents were used at one time, the remainder deteriorated very quickly, (3) the jams did not keep satisfactorily, every sample showing signs of mould growth within 6 months.

Cherry Jam. The samples of cherry jam were infinitely superior to those made without commercial pectin. By the use of a good grade of powdered pectin, which is flavourless, a well-set jam was obtained, with a definite fresh fruit taste. When this jam was made with the addition of lemon juice or liquid pectin, the delicate flavour of the cherry was lost. The yield of jam was greater and, as with strawberry jam, there was a saving of time, labour and fuel.

Raspberry Jam. There did not appear to be any definite advantage in set in using pectin with this jam. The fruit is one which has a moderately good pectin content, the constituent also being in such a form that it can be extracted with the minimum of cooking, which means that a jam of good flavour, colour, set and yield can be obtained without added pectin. (Samples Raspberry Jam A, B and C.) In "uncooked" or "cold process" raspberry jam, however, when the fruit was only heated to 170° F. instead of 212° F. and there was little or no extraction of the natural pectin, it was necessary, for good results, to use commercial pectin.

Gooseberry, Black Currant and Plum Jams. Perfectly satisfactory jams can be made from these fruits without the addition of pectin, but the experiments were carried out because the manufacturers of pectin recommend its use for all fruits irrespective of their natural pectin content.

As the result of experiments with these fruits the following points of interest emerged:—

1. By the addition of pectin the fruits seemed to disintegrate more quickly and the skins became softer than by the ordinary method of jam-making. The result was that the added water was not all evaporated, as is so often the case by other methods, and

therefore the yield of jam was greater and the flavour was more like that of fresh than cooked fruit.

2. When the quantities of water recommended by the pectin manufacturers were used the resulting jams were too stiff. When the proportion of water was doubled very good results were obtained. (Samples B for these jams.)

Conclusions.

1. There is not an equal case for the use of pectin with all jam fruits but, where there is a deficiency of this substance in the fruit, the experiments show that, by the addition of powdered commercial pectin, a really satisfactory jam can be made, superior in every respect to that made from fruit and sugar only. The use of commercial pectin of known strength is a more reliable method of producing satisfactory jams with fruits lacking in pectin content than is the employment of juices of high pectin content such as gooseberry or red currant.

2. The case for the addition of pectin to raspberry jam was not proved for the particular recipes tested (Table II, Raspberry Jam, Samples A, B and C), the resulting jams with and without pectin being very similar in quality. In the case of hard fruits, although pectin is unnecessary from a setting point of view, its addition appeared justified on the grounds of superior flavour and better yield.

3. Regarding the soft fruits, strawberry, cherry and raspberry, if the amounts of sugar suggested by the firms making the pectins were used, the resulting jams were too sweet and there was a definite tendency for the sugar to crystallise out. When the quantity of sugar was reduced or, as in the case of some of the strawberry samples, a proportion of acid such as tartaric was added, the flavour was greatly improved and no crystallisation was noticeable after 6 months' keeping (Strawberry 1932, Samples F and I, and Cherry and Raspberry 1933, Sample B).

4. The particular samples of powdered pectin used gave better results than those of liquid pectin as regards flavour, colour and keeping quality. The setting qualities of the two types of pectin were similar. It was impossible to detect the presence of powdered pectin by taste. Because of some difficulty in dissolving, powdered pectin needed a little more care in using than the liquid preparation, but its advantages appeared to outweigh this disadvantage.

5. The process of making was simplified in every case by the use of pectin and, as is shown in the Tables I and II, there is also considerable saving of time, labour and fuel.

DEFECTS IN CRICKET BAT WILLOW TIMBER.

By H. P. HUTCHINSON.

The value of bat willow timber is largely affected by the amount of blemish shown in the finished bat. Research on the causes of defects due to trapped bark, curvature of grain and stain has revealed the following facts :—

Trapped Bark.

This term is applied to bark which occurs internally in willow timber, its presence being due to the overgrowth of bark by wood tissue. According to the sources of origin, two kinds exist, viz., that of the original set, which might be called “ Trapped Set Bark,” and that which is formed later during the growth of the tree.

Increase in girth of a freshly planted willow set is due to the activity of the cambium layer. If the set be young—*i.e.* two or three years old—and healthy, the whole of the cambium becomes active, increase in girth is uniform for all parts and fusion between the newly-formed wood and that of the set is complete. Frequently, however, in the cases where sets of greater age than three years are planted, cambial activity is restricted and may be confined to isolated patches or zones at different places in the stem. The effect of this is that the resulting dead areas become overlapped by growth of the live cambium on their margins, and the bark of the set at these places becomes overlapped by the new wood. These facts explain why in certain cases the original set with its bark on, forms a core in the middle of the tree which is readily detachable when the tree is felled and cleaved.

Wounds, due to the removal of side shoots prior to the set being planted, and those arising as the result of the removal of lateral branches which have been permitted to grow from the bole of the young tree, ultimately become closed by the ingrowths of tissues from their margins. In this way two bark surfaces come in contact in a vertical plane forming a fissure in the tree trunk which may be permanent throughout the lifetime of the tree. Frequently in cases where the original wounds were small, the contact faces of

bark become broken by the forces of growth whereby union of the cambium tissues on each side of the fissure becomes possible, and the cambium ring of the trunk is restored. The development of wood over the original wound completely hides the enclosed bark which is not seen again until the tree has been split into clefts or when the cleft is being shaped into the bat blade.

Curved or Twisted Grain.

A good bat is straight in the grain, which means that the annual rings, as seen on both front and back faces, are parallel to the edges of the blade and pass round the butt end in a plane at right angles to the plane of the front face.

It is true that crooked sets frequently develop into straight boled trees as the latter arrive at maturity, from which fact the inference that curved grained timber must have developed from the set in such cases is obviously correct. When the curvature in a young set is long, it may be of no consequence since it would be only slightly perceptible in the 22 inches of the bat blade. When sharp kinks are present in the set, as often occurs as the result of the removal of big lateral branches, the value of the timber is very considerably impaired. However small the scar may be, which occurs as the result of the removal of a side branch, the effects on the arrangement of the wood elements are locally persistent for several years; in many cases the wood which overlies large scars is so curved as to be practically worthless or only fit for making low grade bats.

Minor curvatures are also due to the presence of initial root masses and buds. The action of initial root masses in causing wood curvature can be explained by tracing their development in the growing tree.

Root initials are small groups of cells which become clearly distinguishable from the rest of the tissue at about the twelfth bud, counting from any growing point. At this stage they lie external to, and in contact with, the cells of the cambium layer, being separated from the pith by a narrow cylinder of wood through which a well-defined medullary ray passes. The root initials maintain this position relative to the cambium during the whole of the lifetime of the tree, the cells multiplying and becoming divided into separate masses as the tree increases in age. The cambium ring projects where the initial root masses occur, with the result that the wood also shows sharp projections at these places. In longitudinal section the areas are marked from pith to bark as wavy grained bands running radially.

The amount of twisted grain, *i.e.* the number of initial root masses is a varietal character and appears to be less in the case of *Salix caerulea* than with other species.

Occasionally an unusual arrangement of elements occurs throughout the whole of the wood of a bat willow tree, which results in the development of a wavy grain—the waves occurring in regular order. The waves vary in size but generally number from 6 to 8 to the inch. Such timber used to be prized for the making of presentation bats because of the attractive pattern of dark and light bands. The formation of this type of wood is due to an alternating, oblique right and left arrangement of the wood elements in their differentiation, or to zones of cambium which behave in a similar way.

Curvature due to Buds.

The behaviour of buds in inducing curvature and discolouration may be best understood by tracing their activities from their formation to death, or to their development into shoots.

In the willow, buds have their origins primarily at growing points of stems and this connection with the central tissues of the stem may be traced as long as the bud persists. The transverse section of a stem passing through a bud, *e.g.* the eighth from the apex, shows the bud to be in contact with the pith through a gap in the wood cylinder. This gap is never obliterated and forms a trace consisting of radially arranged tissue which traverses the annual rings of wood in a direction at right angles to the direction of extension growth of the shoot, following the bud as the latter becomes further removed from the centre by the growth in thickness of the stem. This opening in the cambium due to the presence of the buds on the stem results in the formation of curved grain wood around the trace, the structure showing as a narrow horizontal dark coloured band with wavy borders should it be exposed in longitudinal radial section, as frequently occurs on the front face of a bat.

A bud may develop into a shoot at any time from the first to at least the twentieth year. Many shoots die in their first or second year, but a few persist and become permanent branches. When a shoot dies and falls off the scar which is left ultimately becomes covered with new growths of wood having necessarily wavy grain. Such curvature diminishes as the tree grows older, but it persists often for many years. The curvature is always concave relative to the outer surface of the tree and serves as a means of distinction from curvature due to roots which is always convex.

The death of a young shoot is followed by the development of two lateral buds which up to this stage have been small buds attached to the central mother bud in the region of the cortex. These buds become separated owing to increase in girth of the stem. Their further growth resembles that of the mother bud except that they do not leave traces in the wood. Each forms two small lateral buds. Should the centre bud develop into a shoot a similar multiplication of buds occurs in the cortex. The local complicated series of twists often present in wood can thus be explained.

Besides the buds which have just been described, another crop of buds develops at the closely arranged nodes at the bases of lateral shoots which have grown for two or more years. These, however, belong to the wood system of the shoot and do not affect the arrangement of tissue in the wood of the main stem.

The removal of laterals which have been allowed to grow for some years is followed by the development of timber so badly curved as to render the clefts taken from these regions of the bole worthless.

Stain.

Discolouration is the most common of all the faults found in Cricket Bat timber. It is due to various causes, the chief being as follows :—

1. *Variety.* Under equally favourable conditions for growth, the timber of *Salix caerulea* contains less heart wood relative to sap wood than any other species. Further, the heart wood of *S. caerulea* is lighter coloured than in the case of other varieties. This point is important for, although "all white" blades are desired, a strip of heart wood is generally present on the lower edge of bat blades because the demand for bats does not permit the trees to attain a size sufficiently large to allow of two rings of clefts (of which the outer would be white) being taken from them.
2. *The presence of concealed snags.* Many dissections of fully grown bat willow timber have shown stained bands to have their origins in the short dead snags of deciduous shoots which developed on the young stem during the first or second year of its life. These bands take a radial horizontal course from the snag through the wood and keep pace in their extension with the bole as it increases in thickness ; generally the end of the stain lags three years

behind the last formed wood. Where such snags occur in series, as from one node of the stem to the next, the discolouration band of one snag is connected with that of the next and shows as a festoon when exposed in radial section. As stated, this discolouration is accompanied by wood curvature.

The snags which remain on the bole as a result of the removal of side shoots which have been allowed to grow for a few years often act as centres from which a considerable amount of stained timber develops. Probably more Bat Willow trees are refused by willow merchants for this, than for any other reason. In most cases external evidences on the tree exist which indicate that stained timber is present. The chief mark is known as "burst," and may be described as a splitting of the bark in a horizontal direction. Exudations of liquid may take place at these points. This form of stain is generally deep seated, frequently having its origin in the dead ends of the side shoots which have been removed at the time when the set was planted.

Stained timber is also caused by the internal decay of wood following the removal of big upper branches, and by the presence of the Watermark disease. (1)

"Fleck" or "Speck" is the term used to denote the short discoloured streaks in the wood. The damage is due to annual attacks by a surface-boring insect of the midge family.

Control Measures.

The research work on this subject carried out at this Station having elucidated the causes of these defects, it now becomes possible to make practical recommendations whereby many of them may be avoided. At this time it is not possible to support these recommendations by data obtained from experiment, since several years must still elapse before the oldest bat willows at the Station will be large enough to provide the required information.

Trapped Bark. This can be avoided by planting vigorously growing sets, as a rule not older than 3 years. Sets which show poor growth should not be used. The sets should be entirely bark covered at the time of planting, *i.e.* all side shoots should have been removed in time to permit the scars to become covered with new bark.

Curved Grain. The sets should be straight at the time of planting. Long gradual curves are of little consequence, but the sharper

the angle at a kink the worse will be the effects. All later branches which appear on the bole while the tree is growing should be cut closely back as soon as they are observed. In order to comply with this requirement sets should be raised under nursery management. The effects on the wood due to the presence of buds cannot be overcome, but they can be reduced by planting *S. caerulea* under the best conditions because, in securing the greatest rate of growth, buds become more widely distributed on the stem and the tree sooner reaches the condition when bole branches no longer develop. Curvatures due to roots can be best avoided by the same measures.

Stain. The correct variety should be planted. Lateral shoots which lead to the formation of snags should not be allowed to develop.

All shoots should be cut back flush with the stem, whether they are found dead or alive.

Where a side branch has become large in a tree approaching its full size, it would be better to leave it than to remove it.

Sets should not be planted if taken from trees in a "Watermark" affected district.

Particular information dealing with the best methods of cultivation of the Cricket Bat Willow have already been published (2, 3).

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REPORT ON ADVISORY WORK, 1932-33.

The number of enquiries received in the Department during the year shows a further large increase over that of the previous period. The gross increase shown in the statistics given below is 802, but the figures for the current year include 42 enquiries received under the heading of "Disease Control Materials and Methods" which subject was not considered in the previous year's enquiries, due to the illness of the officer in charge of that section. The nett increase for the year is thus 760.

It will be seen from the table that during the past six years the number of enquiries has risen from 1528 to 4122, and from this the marked increase in the advisory activities of the Department will be obvious.

In considering the volume of advisory work for the previous year in the last report, it was thought improbable that any considerable increase would be shown in the present period, since the officers concerned for the various sections had worked at very high pressure during 1932. It should thus be emphasised that the present high level is only possible by the whole of the advisory staff working very strenuously, in addition to considerable calls being made on the time of research workers at Long Ashton in connection with advisory problems. The part played by certain sections of the Long Ashton staff in establishing the large recorded increase in the present year will be evident from the fact that, of the total increase of 760, 552 of these additional enquiries were due to the subjects of Economic Entomology, 216, Pomology, 192, and Cider and Fruit Products, 144.*

The substantial increases in these subjects are largely the direct result of the appeal which certain phases of the recent research work in these sections have made to fruit growers and to manufacturers interested in fruit products.

In Economic Entomology, the results of the Station's investigations relating to apple sawfly control, winter washes, mixed spring

* Cider and Fruit Products have been considered together previous to 1933. The figure is a *nett* one for Cider, Cider Instruction and Fruit Products since the subjects have been closely linked during 1933 owing to changing conditions within the sections.

washes, and control of raspberry and loganberry beetle have been responsible for a very rapid increase in advisory work during the past two years, increases of 212 and 216 being recorded for 1932 and 1933 respectively. The increase in Pomology appears to be mainly the result of renewed interest in the planting of both commercial and cider orchards, the management of farm orchards, especially spraying problems, planting of soft fruits and pathological problems of strawberries, all of which subjects have received special attention at Long Ashton during the past few years. In the sections concerned with cider and fruit products, the latter subject has been largely responsible for the large increase in enquiries. During the past two years the officer in charge of the products research has made appreciable advances with problems concerning the use of low grade fruits for the manufacture of various classes of fruit drinks, pectin and other products, and the work has attracted much attention from manufacturers and growers interested in the problems.

Advisory work is now classified under 15 heads : viz., Agriculture and Agricultural Chemistry, Dairy Bacteriology, Agricultural Economics, Veterinary Science, Poultry Pathology, Cider, Cider Instruction, Pomology, Horticultural Chemistry, Economic Entomology, Economic Mycology, Disease Control Materials and Methods, Fruit Products, Domestic Preservation of Fruit and Vegetables and Willow Growing. Statistics relating to enquiries are available for all subjects excepting Agricultural Economics, where the method of working does not lend itself to the statistical tabulation of enquiries, since the personnel of the section concentrate on special problems of groups of farmers, and economic surveys of farming methods and specialised rural industries, and do not consider to any extent the special cases of individuals other than as they arise in group and survey studies.

Of the fourteen† sections for which statistics are available the following increases and decreases respectively were recorded :—

Agriculture and Agricultural Chemistry (+ 62), Dairy Bacteriology (+ 10), Veterinary Science (+ 73), Cider (+ 145), Cider Instruction (— 114), Pomology (+ 192), Horticultural Chemistry (— 1), Economic Entomology (+ 216), Economic Mycology (— 8), Disease Control Materials and Methods (+ 42)—no statistics for 1932, Fruit Products (+ 113), Domestic Preservation of Fruit and Vegetables (+ 6), Willow Growing (+ 43).

† Poultry Pathology is not considered in the following paragraph since the present year constitutes the first working year of the section.

It will be noted that there was a large decrease in one subject only, Cider Instruction, which was due to the withdrawal of Dorset from the Scheme on March 31st, 1932, and of Monmouth on March 31st, 1933.

In addition to the specially large increases discussed above, it will be noted that substantial additions were also recorded for Agriculture and Agricultural Chemistry, Veterinary Science and Willow Growing. Enquiries in Domestic Preservation of Fruit and Vegetables have remained practically stationary as a result of the policy followed by the Instructress, and referred to in the previous report.

The numbers of enquiries submitted to the Department during the past six seasons are summarised in the following table:—

	Year ending September 30th.					
	1928	1929	1930	1931	1932	1933
Gloucester (including Bristol) ..	229	230	365	414	871	849
Hereford	100	118	137	159	169	310
Somerset	336	325	482	553	578	810
Wiltshire	206	235	219	265	343	481
Worcester	162	148	256	323	399	455
Other Areas	495	721	1025	919	960	1217
	1528	1777	2484	2633	3320	4122*

* Statistics available for Poultry Pathology are not included.

The figures under "Other Areas" include enquiries received from Devon and Monmouth, both of which contribute annual grants to the Long Ashton Institute, and from Dorset which participated in the Scheme for Local Instruction in Cider Making until March 31st, 1932.

None of these counties rank officially as part of the Bristol Province, though an arrangement is in force whereby Monmouth is recognised as part of the Bristol Province for Advisory purposes relating to Horticulture.

The data do not include numerous enquiries dealt with in personal interviews during survey work, local investigational work, shows, etc.

The following features referred to in the sectional reports which follow call for special mention.

Agriculture and Agricultural Chemistry.

Once again an increase in the number of requests for advice is

recorded, and difficulty is now being experienced in dealing promptly with enquiries owing to the ever increasing volume of work and the relatively small staff available to deal with it.

A number of important investigations have been concluded during the year. These include: (a) The Longleat Grazing Experiments, a full report of which has been published*; (b) The Seasonal Variation in the Nutritive Value of 2nd Grade Cow Pastures in the West of England, and (c) The Development Commission Pasture Experiments.

Many investigations in connection with grassland problems are still in progress, and amongst these Teart land must be mentioned. Owing to the unusual summer drought of 1933 no serious "teartness" developed; in fact, farmers in the teart area reported that fields which were normally teart at that time of the year provided instead most valuable grazing when other fields on the farm were burnt up. The programme of experiments in the teart area, outlined in the previous report, will be followed during the coming season if conditions are suitable.

The financial assistance of the Agricultural Research Council of the Bath and West Society in connection with grassland investigations is again gratefully acknowledged.

Dairy Bacteriology.

Owing to a change of Staff in this Department in the early part of the year, and to the subsequent prolonged illness of the newly appointed Dairy Bacteriologist, it was not possible to engage upon any new investigational work. Every effort was made by the temporary Bacteriologist to maintain the work already in progress, but prime consideration was given to routine advisory work which was very successfully conducted under difficult conditions.

Agricultural Economics.

Arising out of the special investigations in connection with milk and poultry management schemes, there has been a marked increase in the volume of advisory work. This increased interest in agricultural economics may also be attributed in part to the re-organisation schemes of the Ministry.

The results of the survey of Willow Growing in Somerset have been published in a University Bulletin and demands for this bulletin from growers and others interested have been very numerous.

*Jour. Bath and West Soc., Vol. VIII, 1933-34.

The considerable fluctuations in market prices have made it difficult to test the efficiency of farm management by the usual methods and the economist is now engaged upon evolving a new technique.

It is pleasing to record that the Wiltshire Agricultural Accounting Society is taking a still greater interest in the problems of farm economics.

Veterinary Science.

In this section of the advisory service, as in others, an increase in the volume of advisory work is recorded. The Veterinary Adviser calls special attention to the seriousness of lamb dysentery and Johne's disease in the Province, and he reports that excellent results have been obtained from the use of anti serum in connection with the former disease.

Poultry Pathology.

The establishment of the Poultry Pathological Laboratory referred to in the previous report, appears fully justified, for although the number of samples of blood of poultry received in connection with Bacillary White Diarrhoea has not been as large as was anticipated, it is significant that 53,000 such samples were received during the year and that over 400 post mortem examinations were conducted. The existence of the laboratory has made it possible for the Veterinary Adviser to be relieved of much of the work concerning the diseases of poultry and in consequence he has been able to devote much more of his time to the diseases of cattle, sheep and pigs. The Poultry Pathological Department was established for the benefit of poultry keepers in the Province and its existence depends entirely upon their full support.

Economic Entomology.

The demand for advice in this subject was again exceptionally heavy, an increase of 216 enquiries over those of 1932 being recorded, and resulted in abnormally heavy calls on the time of both the official adviser and the Station entomologist, who have co-operated closely in dealing with the enquiries.

As previously stated a great stimulus has been provided to advisory activities in this subject by investigations carried out at Long Ashton on the control of various fruit pests, but in addition to this, horticultural pests in general, and more particularly glass-house pests, have called for very serious attention during the year.

The more important investigations in progress during the period, other than those concerning fruit pests, related to the control of the *Chrysanthemum* eelworm, which causes a leaf blotch, the control of a strain of *Heterodera schachtii*, the potato eelworm, prevalent on peas, and the use of a seed dressing for the control of Flea Beetles on root crops.

Economic Mycology.

The range of crops covered by advisory work in economic mycology continues to be very large and includes fruit, vegetables, hops, basket and cricket bat willows, cereals and miscellaneous agricultural and horticultural crops.

The special investigations on vegetable diseases have been continued and, as will be seen from the Progress Report to be published in the Long Ashton Station Report, further important practical results have been secured. Mr. B. O. Mulligan continued his field work in the Evesham area during the summer and was in close touch with growers. Many inquiries are now coming in from seedsmen and others in various parts of England and from other countries.

The work was made the subject of an exhibit at the Royal Horticultural Society's Chelsea Show on May 24th to 26th.

Of diseases of fruit trees under investigation, die-back of apples and apple fruit spots and rots should be mentioned. A paper has been published on the apple die-back associated with *Valsa ambiens*.

Strawberry fruit rots, leaf spots, root rots and other diseases of strawberries are being worked on.

Considerable time was again devoted to diseases of basket and cricket bat willows.

Downy mildew of hops did not cause much damage in 1933, owing to the very dry season.

The wilt of China Asters prevalent in the south-west has been found to be due to species of *Fusaria*. Seeds of resistant varieties were obtained from the U.S.A., and several of these have proved to be highly resistant to our strains of *Fusaria*.

The Advisory Mycologist, who is a specialist on lily diseases, has been appointed to the Lily Committee and the Lily Research Sub-Committee of the Royal Horticultural Society.

Advice has been given to growers on many diseases of ornamentals.

Foot rots of cereals due to *Ophiobolus graminis* and *Fusaria* appear to be prevalent in the Province.

Willow Growing.

A feature of outstanding importance to Somerset willow growers during the year was the publication of the Survey of the Willow Growing Area in Somerset. The survey serves to show the present economic status of the industry and to illustrate the problems which exist in connection with the growing and marketing of the basket willow crop.

During the period under review there has been considerable activity in the planting of cricket bat willows and of varieties of osiers suitable for making fruit baskets, the latter impetus possibly resulting from the tariff recently placed on imported baskets.

Spraying experiments with Derris dusts have shown that the Beetle, *Phyllodecta*, can be controlled by these materials, a fact of great importance to the basket willow grower, since no practical and efficient method of controlling the pest had previously been worked out.

Investigations on hand on the raising of selected varieties of tree willows and of bat willow hybrids are likely to prove of great importance to the willow timber trade.

Before proceeding with the more detailed accounts of the advisory activities of the various sections, the personnel of the Department, and in particular all the special Advisory officers, wish to place on record their very keen appreciation of the valuable co-operation and help which they have received from the County Agricultural Staffs and from farmers and fruit growers of the Province in carrying out much of the advisory work herein described.

The salient features of the work of each section during the year are summarised below.

AGRICULTURE AND AGRICULTURAL CHEMISTRY.

During the year under review there has been a further increase in the number of requests for advice received, particularly in connection with grassland problems, feeding stuffs, fertilisers, lime, limestones and water used for stock.

The grants from the Agricultural Research Council and the Bath and West Society for grassland investigations have been renewed

and, as a result of this financial assistance, it is hoped that a comprehensive report on this section of the Department's activities will be issued some time in 1934.

As in former years specimens of weeds and herbage plants have been received for the purpose of identification and report as to commercial value, poisonous properties, etc., and the co-operation of the Department of Botany of the University is readily acknowledged, as also is that of the Department of Geology.

A soil and utilisation survey of the Bromham area of Wiltshire which was conducted in collaboration with the Agricultural Organiser for that County has now been completed and a report will be published early in the New Year.

During the year ending September 30th, 1933, 433 requests for advice were received, which is an increase of 63 over the previous year.

614 samples were examined in the laboratory, and 185 advisory visits were paid.

A few notes on some of the samples are appended :—

Soils.

Most of the soils were concerned with the problems of soil deficiencies in either lime or plant food.

Fertilisers.

The fertilisers received were mainly those not falling within the purview of the Fertilisers and Feeding Stuffs Act and generally consisted of local by-products—hair, hoof, hide, meal, etc. Such substances as poultry manure were received for the purpose of ascertaining the difference in composition after various periods of feeding on different rations, *e.g.* for laying and fattening.

Feeding Stuffs.

The majority of feeding stuffs submitted were suspected of having caused digestive troubles amongst various types of stock, sharps and very finely ground middlings, together with an increased number of poultry foods, being the most common. A few samples were received of compound substances which purported to supply one or other mineral element, *e.g.* iodine, which may be deficient in the usual rations. The analysis of these substances did not always support the extravagant claims made by the vendors.

Limes and Limestones.

The increased number of limes and limestones indicates that local firms are making keener efforts to market their limestone by-products. Some of these constitute promising sources of lime for agricultural purposes if attention is paid to their degree of fineness of grinding.

Waters.

The long continued period of drought resulted in a number of water samples being sent in for the purpose of deciding upon their fitness or otherwise for dairy or domestic purposes. The results of analysis indicate that the water supply on many farms is unfit for drinking purposes both by animals and human beings.

Hay and Forage Crops.

A number of requests for information as to the nutritive value of samples of hay and forage crops were received.

Investigations Completed During the Year.

(1) Grassland.

(a) *The Longleat Grazing Experiment*.—A full report on the results of these experiments has been published.

(b) *The Seasonal Variation in the Chemical Composition of 2nd Grade Cow Pastures in the West of England*.—Data in this connection have been collected during the past five years, and the results are summarised in the following table :—

Percentage of Dry Matter.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Crude Protein ..	14	15	16	19	19	13	16	16	15	16	15	16
Digestible Crude Protein ..	8	9	9	14	14	10	12	12	11	11	9	9
Crude Fibre ..	25	24	22	23	21	26	23	23	23	24	25	25
Starch Equivalent	47	47	51	72	68	66	70	68	72	62	51	47
Lime (CaO) ..	0.9	1.2	1.0	1.1	1.2	1.1	1.1	1.2	1.1	1.2	1.2	0.9
Phosphoric Acid (P ₂ O ₅) ..	0.7	0.8	0.6	0.7	0.7	0.6	0.7	0.7	0.7	0.8	0.6	0.8

The table above indicates the relatively high feeding value of winter herbage and also the low protein content of the herbage of cow pastures in June in the West of England. This latter feature of natural pastures is reflected in milk yields, which inevitably fall off towards the end of June and the beginning of

July. During this period the feeding to cows on grass of a supplementary ration more approximating to a winter ration has produced good results. The ash analysis of many herbage samples has shown that the Lime/Phosphoric Acid ratio of first class West of England herbage is approximately as 1.5% : 1.2%. It would appear therefore that the lime content of natural pastures is slightly below the requirements for first class grazing as also is the phosphoric acid content, and that the Lime/Phosphoric Acid ratio is wider than the average for really good pasture.

(c) *Development Commission Pasture Experiments (1929-1932).*—Two small plots were established on typical Wiltshire Down herbage in 1929. One plot was intensively manured with nitrogen and cut at three-weekly intervals, and the other was cut but not manured. A third area was cut for hay once a year. The effect of the treatments on the yield of dry matter is shown in the following table :—

Year.	Yield of Dry Matter lbs. per acre.		Gain %. From Manuring.	Yield of Hay (lbs. dry matter per acre).
	Plot A. Manured and cut.	Plot B. Cut only.		
1929	628	186	238	—
1930	1481	283	424	1511
1931	1722	677	154	559
1932	1287	658	96	442

(2) Arable Land.

Basic Slag as a Phosphatic Manure for Sugar Beet.—Experiments conducted in Hereford, Gloucester, Wiltshire and Worcester on acid sandy soils have demonstrated the great value of this fertiliser in the growing of sugar beet.

Investigations in Progress.

- (1) The effect of mole draining on the mechanical and chemical composition of the soil.
- (2) The Teart lands of Somerset. Owing to the drought it was not possible to proceed with the investigation mentioned in the previous report. Under the climatic conditions prevailing during the summer of 1933, no "teartness" developed, in fact farmers in the "teart" area reported that fields which were normally "teart" at that time of the year provided them with most valuable grazing when the other fields on the farm were burnt up.

- (3) The effect of simple manurial systems on the nutritive value of pastures.
- (4) Comparison of the yield and nutritive value of fodder obtained by the practices of:—
 - (a) Grazing.
 - (b) Haymaking.
 - (c) Silage making.
- (5) The nutritive value of winter herbage.
- (6) The effect of poultry on the chemical composition of soil and herbage.
- (7) Nitrogen metabolism in clovers.

DAIRY BACTERIOLOGY.

The requests for advice from both the productive and distributive trades continue to increase. Of the usual problems upon which advice was sought, an increased number of enquiries were made regarding low chemical quality of milk, while many cases of high bacterial count and poor keeping quality were met with during the abnormal drought, which were in great part due to lack of water for efficient cleansing and cooling purposes.

During the late summer, several cases of "ropiness" in milk were reported and investigated.

During the year 1275 advisory samples, and 3697 general samples were examined, and in addition the Dairy Bacteriologist paid 32 advisory visits.

As the present Dairy Bacteriologist did not commence duties until 1st June, 1933, and was later incapacitated for a long period owing to illness, the advisory work has been somewhat limited. He wishes to express his appreciation for the work accomplished by Mr. N. R. Knowles, who deputised for him during his illness.

During the period under review a Clean Milk Competition was conducted in Worcestershire. This competition was of six months duration and attracted 15 competitors. The results were very satisfactory, and it is hoped to organise a similar competition during the coming year.

The Registers of Accredited Producers have been continued in Wiltshire and Worcestershire, there being 32 and 8 producers on the respective rolls.

The milk samples dealt with during the year in connection with the above-mentioned competition and Registers numbered 516.

Investigations.

During the year the following investigations have been conducted :—

- (1) A study of the Methylene Blue Reductase Test as applied in the examination of milk samples.
- (2) The Thermal Insulation of Milk Samples during transit by post.

One series of investigations on these subjects has now been completed and reports issued. Further study is contemplated in connection with the Methylene Blue Reductase Test as time permits.

- (3) The Relative Merits of Hand and Machine Milking in the Production of Clean Milk.

The major portion of this investigation is now complete, but some further work is intended.

AGRICULTURAL ECONOMICS.

1. Enquiries and Advisory Work.

While there has been a decrease in the number of financial accounts analysed and reported upon, there has been a deeper penetration into the work of analysis. Classification of farm results according to types and systems of farming has received more attention than before, and the grouped data are of more use to the farmers concerned. The continued and fairly rapid fall in the prices of most farm products during the last two or three years has made advisory work more difficult when purely financial account data have been relied upon. For this reason analysis of physical quantities is now being made in order to test the validity of financial analysis.

Generally speaking, enquiries come from large farmers and this applies equally to all types of farms, including poultry farms, fruit farms and market gardens. Only a very small proportion of the enquiries come from farmers in a small way of business, and it may be stated that as a general rule the farmer's appreciation of the work in economics appears to increase with the size of the farm. This probably is not to be wondered at, for the value of efficient management must be the more appreciated, the larger and the more complex the problems involved.

It is certain, from what has been said above, that full cost accounting could be greatly extended in the Province if staff and money permitted, and because of the eagerness on the part of some farmers to keep the necessary records, the amount of work per farm which would have to be carried out by the Economist would be lightened. What applies to full costing applies with still more force to simple financial accounts. More attention has been paid during the past year to an extension of the accounting work in the fruit and market garden areas of Worcestershire, and in spite of the acknowledged complexity of accounting for such holdings, the amount of interest shown by the growers and the willingness to facilitate any investigation have been very encouraging. For such areas a mere expansion of the usual accounting method is not sufficient, so that it has been necessary to devote attention to the construction of forms and systems of accounts which will meet their special requirements.

It is in such connections as these that the re-allocation of the work of the Department away from full cost accounts and towards simple financial accounts and surveys has enabled a better grasp to be made of the economic position of the Province as a whole. The field of work is considerably widened and the problems of several types of farming are capable of being attacked.

Evidence gathered by close study of financial accounts and the treatment of the results by statistical method seem to point to the danger that farmers in their anxiety to reduce costs may move so far towards grassland that their farms become unbalanced. That is to say, the point is reached when diminishing returns set in strongly, for any saving in one direction, *e.g.* labour costs, is offset, usually more than offset, in other directions, *e.g.* by higher costs in the shape of the food bill, or by lower turnover owing to decreased intensification. Because of this a "ploughing up" policy has been advised on several farms.

2. Investigation Work.

The following summary is given,

(a) *Costing.*

<i>No. of Farms.</i>	<i>Total Acreage.</i>
3	965

(b) *Financial Accounts.*

Simple financial accounts are being received from 155 farmers. The reduction in numbers as compared with the previous year is part of the rationalisation of the department's work. Only by

omitting farmers who cause undue trouble and delay is it possible to find the time for other special studies. The farms, covering 64,520 acres, may be grouped as follows :—

<i>Proportion of Permanent Grass.</i>	<i>No. of Farms.</i>	<i>Type of Farm.</i>
0 — 30%	4	Fruit and market gardening .. 3 Milk 1
31 — 70%	68	Fruit and market gardening .. 3 Milk 20 Cattle and crops 9 Mixed 36
71 —100%	83	Milk 35 Cattle and crops 8 Mixed 40
	155	155

(c) *Special Investigations.*

- (i) The strawberry costing investigation is being continued on 30 farms, comprising 71 acres of strawberries, in order that a second year's records may be available for comparison.
- (ii) The modified scheme of sugar-beet costing is still being carried out on 11 farms in Herefordshire and Worcestershire in order to preserve the continuity of the inquiry which began in 1925.
- (iii) A preliminary statement in connection with the special investigation into dairy herd management has recently been issued to the farmers co-operating. A full report upon the first year's results is now in course of preparation. Thirty-two farmers are co-operating in the scheme. The size of herd varies from 7 to 137 cows and altogether 1120 cows are included.
- (iv) An inquiry similar to the above is being carried on in poultry farming. Thirty-five farmers having flocks ranging from 100 to over 4000 birds are co-operating, and the systems of management vary considerably. The first year of the survey ended last September, and a full report is being prepared.
- (v) The special investigations into the application of statistical methods to farm account data are being continued. The results obtained do not justify the publication of definite,

positive conclusions. On the contrary, the experimental work has demonstrated that the material collected in the financial account is cast in a form which is not designed to answer questions framed by the economic statistician. The statistical research of the department is being directed towards transforming the data of accountancy into data which are capable of economic manipulation.

3. Co-operation.

It is the general practice to seek the co-operation of County staffs when any new investigational work in economics is being undertaken, and the Economist has always received valuable advice and assistance in such cases. The Advisory Economist at Bristol is also working in co-operation with the Economists at Harper Adams Agricultural College and at Armstrong College in the poultry enquiry referred to, and with the Economists at the Universities of Reading and Cambridge and at Seale Hayne Agricultural College in the investigation into the cost of production of strawberries. Data collected at Bristol in connection with the cost of production of sugar beet are as usual being sent to the Agricultural Economics Research Institute at Oxford for comparison with data collected by certain other centres.

VETERINARY SCIENCE.

The number of enquiries and specimens submitted for examination have increased considerably during the past year, so much so that very little time has been available for research other than the investigation of local outbreaks of disease on various farms. Visits to farms have been essential in many cases in order to obtain a clear knowledge of the conditions which prevail and of the problems to be tackled, so that the most economical means of dealing with the disease can be evolved.

363 requests for advice were received, 600 pathological specimens examined and 171 advisory visits paid during the year under review.

Some notes on the diseases of animals encountered in the Province are appended :—

Sheep.

Lamb dysentery caused serious losses during the past spring, the disease being much more widespread than in previous years. The use of anti serum has given excellent results on most farms.

Parasitic gastritis and enteritis in lambs have been encountered on several occasions, the worms present in two outbreaks being of *Ostertagia* species. Dosage with nicotine sulphate solution was tried in these cases with quite good results as far as could be judged from cessation of fatalities and improvement in condition. Unfortunately, it was not convenient to have controls, but the Adviser hopes to make further observations on the efficacy of this drug.

There were a few outbreaks of abortion, both vibronic and paratyphoid, in the Province, and it appears probable that these conditions will spread.

Cattle.

Requests for advice on all the common diseases of cattle have been received, namely, Contagious Abortion, Johne's disease, Mastitis and Calf Scour. Sterility has been very rife in certain areas, most of the animals in these parts being affected with "whites" of a particularly chronic character, extremely difficult to cure.

Johne's disease is still prevalent, particularly in those areas of flat country where a drinking pond supplied by surface drainage is present in every field. Many farmers are, however, gradually improving hygienic conditions generally and are having a proper water supply laid on.

Outbreaks of scour in calves have been successfully controlled by strict sanitary and hygienic precautions.

Pigs.

Losses among pigs have been mainly caused by faulty feeding and hygiene. Large round worms, Pasteurellosis and Swine Erysipelas have been encountered; routine disinfection was found a satisfactory method in dealing with the first two.

Poultry.

Among poultry, paralysis has given rise to a large number of enquiries. Parasites, such as round worms, caecum worms, tape worms and coccidia have been rampant during the year under review, and have been the subject of enquiry and visits to affected farms. Other diseases encountered and dealt with in the usual manner were Bacillary White Diarrhoea, Fowl Pox, Dietetic errors, etc. The use of arsenical compounds for the treatment of Black-head in turkeys is being widely adopted by farmers. One outbreak of Salmonellosis in ducks was encountered.

Investigations.

An investigation into the problem of "teart" land in Somerset was commenced in October, 1932, in collaboration with the Agricultural Officer, Soil Surveyor and Botanist. It was hoped to proceed with feeding experiments on this year's aftermath, but the drought rendered such trials impossible. Next year every opportunity will be taken in an attempt to elucidate this problem.

Trials with Johnin have been continued.

POULTRY PATHOLOGY.

Blood Testing for Bacillary White Diarrhoea.

During the first season, dating from August 22nd, 1932, to July 31st, 1933, 52,879 samples of blood were tested and reported upon. To bring this into line with the rest of the report, *i.e.* up to September 30th, 1933, the number of samples totalled 69,444.

Post Mortems.

The number of birds and batches of chickens examined during the year totalled 404.

Of the fowls, 125 were from the County Egg Laying Trials of Gloucester, Somerset, Wilts and Hereford.

Wherever post-mortem information was insufficient, visits were made, if possible, to the farm and investigations carried out on the spot. In almost every case where a visit was possible and post-mortem examination had been indefinite, sufficient evidence was obtained on the farm to indicate the possible cause of the trouble and remedial measures to be adopted.

In the assistance of the Veterinary Adviser in these duties, 48 visits to farms in the Province have been made.

Egg Laying Trials.

The Poultry Pathologist acted in the capacity of Veterinary Surgeon on the Reception Committee receiving the birds for the current trials at Cannington, Somerset, on September 22nd, 1933, and at Warminster, Wilts, on September 25th, 1933.

CIDER.

621 enquiries, including 94 under the Cider Instruction Scheme in the counties of Monmouth and Worcestershire, received attention

during the year. Of this total, 245 requests came from areas outside the Bristol Province, and included some from Ireland, Jersey, Australia, Canada, New Zealand, Tasmania, U.S.A., France and Denmark.

In connection with the enquiries, 77 analyses of cider and 59 estimations of alcohol were involved, besides a considerable number of determinations of volatile acid and sulphur dioxide, and analyses of dried pomace. Several visits were also made to cider factories, farm cider-makers and farm orchards.

Many applications for advice concerned the use of new types of metals for use in cider manufacture and tests were carried out with certain of these to determine their resistance to different types of cider and to cider vinegar. The materials included Austenitic cast iron, inco chrome nickel, stainless steels of various composition and acid resisting bronzes.

Other special features were general requests for advice on cider making from fruit growers and others interested in the utilisation of surplus apples, especially from the fruit areas in the Eastern Counties; the selection of high grade apple varieties for cider making and the storage of cider during the abnormally hot summer.

The county of Monmouth withdrew from the Cider Instruction Scheme at the end of March, 1933, so that from that date, the county of Worcester alone has remained under the Scheme.

The instructor, as in previous years, paid numerous visits to cider apple growers and to farm-cider makers, giving his personal attention in many cases to the various operations concerned in the making of high class bottled ciders. Attention was also paid to problems of cider orcharding.

In Monmouth, he co-operated with the County Staff at the Usk Agricultural Institution in connection with the milling and pressing of fruit of farmers by the Institute plant.

POMOLOGY.

538 enquiries were received, including 235 from areas outside of the Province. Several requests emanated from Scotland, Ireland, Wales, South Africa and U.S.A., and two each from Canada and Germany. The total shows an increase of 192 over the previous year. 119 visits were paid in dealing with the enquiries.

The subjects of enquiry covered many aspects of fruit production,

but the following were especially prominent : the planting and care of cider orchards and commercial fruit plantations ; spraying technique for orchards and plantations, and costs of spraying ; rootstocks for apples and plums ; head-working of newer commercial apple varieties on older sorts ; methods of establishing and managing stool beds ; various problems of strawberry culture, including control of various pathological troubles and pollination problems of Oberschlesien and Tardive de Leopold. Enquiries were received from several nursery firms relating to the subjects of raspberry varieties and diseases of raspberries, and the raising of cider apple trees for West Country orchards.

The pomological survey of the Evesham and Pershore fruit areas was completed, and a report is being prepared.

HORTICULTURAL CHEMISTRY.

122 enquiries, including 39 from sources outside the Province, were received.

The subjects of enquiry were similar to those of previous seasons, but requests relating to the planting of new fruit sites and to physiological disorders of fruits, such as cork, water core and bitterpit were especially prominent. These latter disorders were doubtless the result of the abnormally dry and hot summer, since they are caused primarily by high temperatures and drought.

Investigations in Progress.

1. *Experiments on the Control of Lime-induced Chlorosis in Apples, Pears, Plums and Garden Crops—in Somerset and Worcester.*

In the case of the various classes of fruit trees, the effects of injections of iron citrate into stems and branches are under investigation. Trees were treated at 4 centres, using powdered iron citrate, after the method of J. P. Bennett. The results obtained are very encouraging, very large responses being obtained, but it remains to be seen how long the treatments will remain effective.

The results obtained on garden plants from dressings of ferrous sulphate applied to the soil indicate that the method is not likely to prove of much use in controlling chlorosis.

2. *Survey of Soils in the Fruit Areas on the Lower Lias Formation.*

Work was commenced on the Martock area in Somerset and is combined with a survey of the Teart Land Areas in that district. So far the work has been chiefly of the nature of a reconnaissance of the main soil features.

The report on the Survey in the Evesham - Pershore area is practically completed. Detailed soil maps have been made.

ECONOMIC ENTOMOLOGY.

The number of enquiries received was 780, which again shows a substantial increase over that of the previous year (+216). Personal visits totalled 130. The main subjects of enquiry were: the control of Apple Sawfly, Codling Moths, Tortrix Moths and Red Spider on apples; Raspberry Beetle and Capsid Bugs on black currants; use of winter washes and wetting agents; the preparation of combined insecticidal and fungicidal washes for summer use; strawberry pests; glasshouse pests, especially chrysanthemum eelworm; *Heterodera schachtii* on peas; flea beetles on root crops.

The main investigations in progress were as follows:—

Apple Sawfly (*Hoplocampa testudinea*).

This pest has assumed serious proportions in commercial apple plantations during the past three or four seasons, and for this reason comprehensive series of tests were carried out in commercial plantations to determine the most appropriate spraying programme against the pest. The experiments demonstrated the great importance of correct timing of spraying operations and of very thorough application of the spray fluids. The results were very successful and are of enormous importance to apple growers.

The Control of Capsid Bugs on Black Currants.

In view of the failure to control this pest by means of winter washes, experiments have been carried out to test the efficiency of nicotine and derris dusts and nicotine washes as summer applications. Only the last gave good results.

Raspberry and Loganberry Beetle (*Byturus tomentosus*).

Special attention was given to the control of this pest under

conditions when the beetles did not assemble on the flowers in large numbers over a short period. Satisfactory results were obtained by the use of derris washes and dusts applied as larvicides after the date of full petal fall.

Codling Moths and Tortrix Fruit Moths.

Preliminary tests have been made to control these pests, the former by late application of mixed insecticidal washes used in the apple sawfly programme.

The codling moths can be largely checked in this way.

Red Spider on Fruit Trees.

Experiments have shown that this pest may not be controlled with a full lime sulphur programme on apple trees unless an efficient wetting agent is used and the applications are carefully timed. Control can be obtained by means of a White Oil emulsion used with an efficient wetter.

Mixed Summer Washes for Apple Trees.

Trials were made with mixed summer washes for post blossom application to apples for the control of Apple Sawfly, Capsid Bugs, Caterpillars, Red Spider, Codling Moths and Apple Scab. Various washes can now be recommended against certain combinations of these pests and scab.

Chrysanthemum Eelworm (*Aphelenchoides ritzema-bosi*).

Experiments were continued on various methods proposed for the control of this pest, including cleansing of "stools" with hot water sterilisation, and treatment with nicotine and maura meal.

***Heterodera schachtii* (Pea and potato strains).**

Numerous tests in connection with these pests were made, including variety trials of peas, observation on weeds and crop plants as hosts, and control of the potato strain with formaldehyde treatment of the soil.

Flea Beetles.

A survey of flea beetles attacking root crops in the Province is in progress, and various control measures are being tested. Treatment of seed with a mixture of paradichloro-benzene and naphthalene gave good results.

Hops.

Survey methods are being employed as an initial measure in an attempt to determine the possible relationships between various pests and the spread of virus diseases of hops.

ECONOMIC MYCOLOGY.

The number of advisory letters despatched during the year was 327, compared with 335 last year.

The following is a summary of the chief diseases under investigation :—

Fruit.

Die-backs of apple trees associated with *Valsa ambiens*, and cankers associated with certain feebly parasitic fungi; fruit spots and rots of apples, especially those due to *Gloeosporium album* and *Sphaeropsis malorum*, and the twig cankers on which these fungi appear to occur; strawberry leaf spots, fruit rots and root rots, and certain obscure strawberry diseases.

Vegetables.

“ Halo blight ” of dwarf beans (*Bacterium Medicaginis* var. *phaseolicola*); foot rot of dwarf beans (*Fusarium spp.*); wilt of runner beans (*Fusarium spp.*); leaf and pod spots and foot rots of peas; pea mosaic; control of “ white tip ” of leeks (*Phytophthora Porri*); foot rot of leeks (*Fusarium sp.*); control of onion white rot (*Sclerotium cepivorum*); mint rust (*Puccinia Menthae*); control of potato “ sickness ” (*Heterodera schachtii*); vegetable marrow mosaic; violet root rot of asparagus (*Rhizoctonia Crocorum*) and *Zopfia rhizophila*; parsnip “ canker ”; and ring spot (*Marssonina panattoniana*) and *Botrytis* on lettuces.

Further substantial progress has been made in the investigation of the above vegetable diseases, the main points of interest being described in the special article devoted to the subject in the Station Annual Report.

Ornamentals.

Freesia mosaic; delphinium root rots; aster wilts caused by *Fusaria*; lily root rots.

Miscellaneous.

Willow rusts ; canker of cricket bat willows ; virus diseases of hops.

DISEASE CONTROL MATERIALS AND METHODS.

Advisory work in this section was again considerably disorganised during the year by the prolonged illness of the officer responsible for the section. In his absence enquiries were dealt with as far as possible by the Research Mycologist and the Research Entomologist.

The number of enquiries dealt with by these officers was 42.

A large proportion of the enquiries concerned the uses of winter washes, wetting compounds and new fungicidal washes and dusts, whilst several samples of new fungicides, mainly copper-lime dust and copper-containing sprays, and new wetting compounds were submitted by manufacturers for opinions of the values of the materials for specific purposes.

DOMESTIC PRESERVATION OF FRUIT AND VEGETABLES.

230 enquiries were received during the year, exclusive of letters dealing with lectures, summer courses, judging at produce shows, etc. The number is similar to that of the previous year, and was not expected to be appreciably higher in view of the steps taken by the Instructress to deflect advisory requests to various local centres. As in previous years a very large proportion of the enquiries (191) came from centres outside the province, which is to be expected since the Instructress is in touch with all counties of the country. Several enquiries were also received from Scotland and Wales, and a few from India, Ireland, Uganda and South Africa.

The main subjects of enquiry were as follows :—The use of commercial pectins ; the canning and bottling of vegetables ; the canning machine and its uses ; making of jams, jellies and marmalade, and setting problems of these ; preservation of fruit in sulphur dioxide ; sugarless jam and marmalade recipes ; preservation of mushrooms ; preservation of rhubarb.

Lectures, Demonstrations and Classes.

These were held under various authorities and organisations at the following centres:—

Lectures and Demonstrations. Norwich, Newport (Isle of Wight), Derby, Shrewsbury, Taunton, Trowbridge, Wimbledon.

Classes. Devon—Exeter, Torrington, Plymouth; Shropshire—Shrewsbury; Warwickshire—Leamington, Rugby, Coleshill; Surrey—Redhill, Guildford.

Summer Courses.

These courses in Fruit and Vegetable Preservation were held at the Royal Agricultural College, Cirencester, from July 18th to September 8th. As in previous years the maximum number of students possible was enrolled for the courses, although applications on this occasion were received later than in previous years.

The greater proportion of students attending were teachers or students of domestic science, the remainder consisting mainly of dairy instructresses, horticultural lecturers and housekeepers in large institutions.

Courses for Women's Institute Demonstrators.

In co-operation with the National Federation of Women's Institutes a special short course in methods of teaching fruit preservation was given at the Royal Agricultural College, Cirencester, during the period September 13th-15th. An examination was held at the conclusion of the course, when 11 of the 12 students attending were successful, five receiving 1st class, and six 2nd class awards of certificates issued by the National Federation of Women's Institutes.

General.

Judging was undertaken at Women's Institute Produce Exhibitions in Dorset, Devon, Warwickshire, Norfolk, Berkshire, Oxford and Derbyshire, and reports made on the exhibits to the authorities concerned.

During the period the closest co-operation has been maintained with the National Federation of Women's Institutes, through which body touch has been kept with various County Federations.

Bulletin No. 21 of the Ministry of Agriculture and Fisheries, entitled "Domestic Preservation of Fruit and Vegetables," has been revised by the Instructress for the publication of the 3rd edition.

FRUIT PRODUCTS.

138 requests for advice were received, of which 84 came from outside of the Province. This is the first year that a considerable number of enquiries have been received under this head, which is due to the fact that 1932 was the first year when it was possible to carry out a comprehensive programme of research in the subject.

The majority of enquiries followed closely the subjects dealt with in the previous years investigations, concerning chiefly the evaluation of dried apple pomace, apple pectin manufacture, production of fruit wines, juices and concentrates.

The enquiries illustrate the variety of problems which continue to arise in the commercial manufacture of apple pectin, and the interest at present taken in the problem of the utilisation of fruit unsuited for dessert and culinary markets. In this latter connection it appears that considerable quantities of fruit syrups and wines have been made during 1933.

WILLOW GROWING.

267 enquiries were received concerning problems of willow growing, which is an increase of 48 over the previous year. The increase was largely due to the great interest at present taken in problems of cricket bat willow culture.

The main subjects of enquiry were : culture and management of the cricket bat willow and of basket willows ; suitability of varieties for various purposes ; the control of pests and diseases.

The enquiries relating to the culture of the cricket bat willow show that regard is now being paid to every phase of production : suitability of soils, sources of supply of sets and methods of planting, the planting of the true variety, raising of sets, manurial requirements, defects in growing trees.

During the year attention has been given to certain points by the adviser with a view to effecting cheaper and more efficient methods of production of basket willows. These include methods

of preparing the land for the crops and, in particular, the use of power units for this purpose; the effects of various manurial treatments in relation to systems of culture under which willows are produced; the designing of spraying outfits suitable for work on willow beds.

This last point is of great importance at present as control methods have been recently evolved for such pests as the Willow Beetle, and it is certain that the control of this pest will greatly increase the yields and qualities of rods, but there are great difficulties experienced in carrying out the appropriate control measures on willow beds due to lack of suitable spraying and dusting outfits.

The Somerset County Willow Beds have been continued as in previous years.

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